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BACKGROUND INFORMATION FOR STANDARDS OF PERFORMANCE: PHOSPHATE FERTILIZER INDUSTRY

VOLUME 1. PROPOSED STANDARDS

ENVIRONMENTAL PROTECTION AGENCY

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This document provides background information on the derivation of the standards of performance for the phosphate fertilizer industry. Volume 1 provides a general description of the facilities for which standards are proposed and provides the rationale for the proposed standards of performance. Included is an analysis of the economic impact of the standards on the industry. The proposed standards require control at a level typical of well controlled existing plants and attainable with existing technology. To determine these levels, extensive on-site investigations were conducted, and design factors, maintenance practice, available test data, and the character of emissions were considered.

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VOLUME 1: PROPOSED STANDARDS

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

October 1974

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PREFACE

A. Purpose of this Report

Standards of performance under section 111 of the Clean Air Act[1] are proposed only after a very detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This report summarizes the information obtained from such a study of the phosphate fertilizer industry. It is being distributed in connection with formal proposal of standards for that industry in the Federal Register. Its purpose is to explain the background and basis of the proposal in greater detail than could be included in the Federal Register, and to facilitate analysis of the proposal by interested persons, including those who may not be familiar with the many technical aspects of the industry. For additional information, for copies of documents (other than published literature) cited in the Background Information Document, or to comment on the proposed standards, contact Mr. Don R. Goodwin, Director, Emission Standards and Engineering Division, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711 [(919)688-8146].

B. Authority for the Standards

Standards of performance for new stationary sources are promulgated in accordance with section 111 of the Clean Air Act (42 USC 1857c-6), as amended in 1970. Section 111 requires

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1/ Sometimes referred to as "new source performance standards" (NSPS).

the establishment of standards of performance for new stationary sources of air pollution which "... may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare." The Act requires that standards of performance for such sources reflect "... the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

Section 111 prescribes three steps to follow in establishing standards of performance.

1. The Administrator must identify those categories of stationary sources for which standards of performance will ultimately be promulgated by listing them in the Federal Register.
2. The regulations applicable to a category so listed must be proposed by publication in the Federal Register within 120 days of its listing. This proposal provides interested persons an opportunity for comment.
3. Within 90 days after the proposal, the Administrator must promulgate standards with any alterations he deems appropriate.

It is important to realize that standards of performance, by themselves, do not guarantee protection of health or welfare; that is, they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect best demonstrated technology (taking into account costs) for the affected sources. The overriding purpose of the collective body of standards is to maintain existing air quality and to prevent new pollution problems from developing.

Previous legal challenges to standards of performance for portland cement plants, steam generators, and sulfuric acid plants have resulted in several court decisions[2] of importance in developing future standards. In those cases, the principal issues were whether EPA: (1) made reasoned decisions and fully explained the basis of the standards, (2) made available to interested parties the information on which the standards were based, and (3) adequately considered significant comments from interested parties.

Among other things, the court decisions established: (1) that preparation of environmental impact statements is not necessary for standards developed under section 111 of the Clean Air Act because, under that section, EPA must consider any counter-productive environmental effects of a standard in determining what system of control is "best;" (2) in considering costs it is not necessary to provide a cost-benefit analysis;

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[2] Portlant Cement Association v Ruckelshaus, 486 F. 2nd 375 (D.C. Cir. 1973); Essex Chemical Corp. v Ruckelshaus, 486 F. 2nd 427 (D.C. Cir. 1973).

(3) EPA is not required to justify standards that require different levels of control in different industries unless such different standards may be unfairly discriminatory; and (4) it is sufficient for EPA to show that a standard can be achieved rather than that it has been achieved by existing sources.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. On the contrary section 116 of the Act (42 USC 1857-D-1) makes clear that States and other political subdivisions may enact more restrictive standards. Furthermore, for heavily polluted areas, more stringent standards may be required under section 110 of the Act (42 USC 1857c-5) in order to attain or maintain national ambient air quality standards prescribed under section 109 (42 USC 1857c-4). Finally, section 116 makes clear that a State may not adopt or enforce less stringent standards than those adopted by EPA under section 111.

Although it is clear that standards of performance should be in terms of limits on emissions where feasible,[3] an alternative method of requiring control of air pollution is sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive.

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[3] "'Standards of performance,' ... refers to the degree of emission control which can be achieved through process changes, operation changes, direct emission control, or other methods. The Secretary [Administrator] should not make a technical judgment as to how the standard should be implemented. He should determine the achievable limits and let the owner or operator determine the most economical technique to apply." Senate Report 91-1196.

For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during storage and tank filling. The nature of the emissions (high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement highly impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

C. Selection of Categories of Stationary Sources

Section 111 directs the Administrator to publish and from time to time revise a list of categories of sources for which standards of performance are to be proposed. A category is to be selected "... if [the Administrator] determines it may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare."

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. In brief, the approach that has evolved is as follows.

First, we assess any areas of emphasis by considering the broad EPA strategy for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are primarily emitted by stationary sources. Source categories which emit these pollutants are then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might result from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of performance for the source category.

After the relative ranking is complete, an estimate must be made of a schedule of activities required to develop a standard. In some cases, it may not be feasible to immediately develop a standard for a source category with a very high priority. This might occur because a program of research and development is needed or because techniques for sampling and measuring emissions may require refinement before study of the industry can be initiated. The schedule of activities must also consider differences in the time required to complete the necessary investigation for different source categores. Substantially more time may be necessary, for example, if a number of pollutants must be investigated in a single source category. Even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling.

Selection of the source category leads to another major decision: determination of the types of sources or facilities to which the standard will apply. A source category often has several facilities that cause air pollution. Emissions from some of these facilities may be insignificant and, at the same time, very expensive to control. An investigation of economics may show that, within the costs that an owner could reasonably afford, air pollution control is better served by applying standards to the more severe pollution problems. For this reason (or perhaps because there may be no adequately demonstrated system for controlling emissions from certain facilities), standards often do not apply to all sources within a category. For similar reasons, the standards may not apply to all air pollutants emitted by such sources. Consequently, although a source category may be selected to be covered by a standard of performance, treatment of some of the pollutants or facilities within that source category may be deferred.

D. Procedure for Development of Standards of Performance

Congress mandated that sources regulated under section 111 of the Clean Air Act be required to utilize the best practicable air pollution control technology that has been adequately demonstrated at the time of their design and construction. In so doing, Congress sought to:

1. maintain existing high-quality air,
2. prevent new air pollution problems, and
3. ensure uniform national standards for new facilities.

The selection of standards of performance to achieve the intent of Congress has been surprisingly difficult. In general, the standards must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost of such control; (3) be applicable to existing sources that are modified as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

A major portion of the program for development of standards is spent identifying the best system of emission reduction which "has been adequately demonstrated" and quantifying the emission rates achievable with the system. The legislative history of section 111 and the court decisions referred to above make clear that the Administrator's judgment of what is adequately demonstrated is not limited to systems that are in actual routine use. Consequently, the search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. To date, determination of the "degree of emission limitation achievable" has been commonly based on (but not restricted to) results of tests of emissions from existing sources. This has required worldwide investigation and measurement of emissions from control systems. Other countries with heavily populated, industrialized areas have sometimes developed more effective systems of control than those used in the United States.

Because the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which the standards are established will necessarily be somewhat limited. Test data on existing well-controlled sources are an obvious starting point in developing emission limits for new sources. However, since the control of existing sources generally represents retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered and judgment is necessarily involved in setting proposed standards.

Since passage of the Clean Air Amendments of 1970, a process for the development of a standard has evolved. In general, it follows the guidelines below.

1. Emissions from existing well-controlled sources are measured.
2. Data on emissions from such sources are assessed with consideration of such factors as: (a) the representativeness

of the source tested (feedstock, operation, size, age, etc.); (b) the age and maintenance of the control equipment tested (and possible degradation in the efficiency of control of similar new equipment even with good maintenance procedures); (c) the design uncertainties for the type of control equipment being considered; and (d) the degree of uncertainty affecting the judgment that new sources will be able to achieve similar levels of control.

3. During development of the standards, information from pilot and prototype installations, guarantees by vendors of control equipment, contracted (but not yet constructed) projects, foreign technology, and published literature are considered, especially for sources where "emerging" technology appears significant.
4. Where possible, standards are set at a level that is achievable with more than one control technique or licensed process.
5. Where possible, standards are set to encourage (or at least permit) the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.
6. Where possible, standards are set to permit use of

systems capable of controlling more than one pollutant (for example, a scrubber can remove both gaseous and particulate matter emissions, whereas an electrostatic precipitator is specific to particulate matter).

7. Where appropriate, standards for visible emissions are established in conjunction with mass emission standards. In such cases, the standards are set in such a way that a source meeting the mass emission standard will be able to meet the visible emission standard without additional controls. (In some cases, such as fugitive dust, there is no mass standard).

Finally, when all pertinent data are available, judgment is again required. Numerical tests may not be transposed directly into regulations. The design and operating conditions of those sources from which emissions were actually measured cannot be reproduced exactly by each new source to which the standard of performance will apply.

E. How Costs are Considered

Section 111 of the Clean Air Act requires that cost be considered in setting standards of performance: To do this requires an assessment of the possible economic effects of implementing various levels of control technology in new plants within a given industry. The first step in this analysis requires the generation of estimates of installed capital costs and annual operating costs for various demonstrated control systems, each control system alternative having a different overall control capability. The final step in the analysis is to determine the economic impact of the various control alternatives upon a new plant in the industry. The fundamental question to be addressed in this step is whether or not a new plant would be constructed given that a certain level of control costs would be incurred. Other issues that would be analyzed in this step would be the effects of control costs upon product prices and the effects on product and raw material supplies and producer profitability.

The economic impact upon an industry of a proposed standard is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing State control regulations. This incremental approach is taken since a new plant would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that usually exists between the standard of performance and the typical State standard.

It should be noted that the costs for control of air pollutants are not the only control costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry as this factor also influences the ability of new plants to generate the capital required for installation of the additional control equipment needed to meet the standards of performance.

The end result of the analysis is a presentation of costs and potential economic impacts for a series of control alternatives. This information is then a major factor which the Administrator considers in selecting a standard.

F. Impact on Existing Sources

Proposal of standards of performance may affect an existing source in either of two ways. First, if modified after proposal of the standards, with a subsequent increase in air pollution, it is subject to standards of performance as if it were a new source. (Section 111 of the Act defines a new source as "any stationary source, the construction or modification of which is commenced after the regulations are proposed.")[4]

Second, promulgation of a standard of performance requires States to establish standards of performance for the same pollutant for existing sources in the same industry under section 111(d) of the Act; unless the pollutant limited by the standard for new sources is one listed under section 108 (requiring promulgation of national ambient air quality standards) or one listed as a hazardous pollutant under section 112. If a State does not act, EPA must establish such standards. Regulations prescribing procedures for control of existing sources under section 111(d) will be proposed as Subpart B of 40 CFR Part 60.

G. Revision of Standards of Performance

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator may revise such standards from time to time. Although standards proposed and promulgated by EPA under section 111 are designed to require installation of the "... best system of emission reduction ... (taking into account the cost)..." the standards will be reviewed periodically. Revisions will be proposed and promulgated as necessary to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after proposal of the revised standards.

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[4] Specific provisions dealing with modifications to existing facilities are being proposed by the Administrator under the General Provisions of 40 CFR Part 60.

H. Why Standards of Performance for Fluorides?

Two questions are basic to the control of fluorides: why control them and why do so with section 111?

The deleterious effects of fluoride on both animals and vegetation have been extensively documented.[5/] The effect on animals is through the digestive tract when relatively large quantities of contaminated vegetation are ingested. Citizens, both privately and in groups, have sought relief from fluoride damage through suits against the alleged industrial sources. In one case, a citizens' group sent to EPA data which support the need for Federal regulation of fluorides. State agencies have recorded and acted on numerous public complaints on the adverse effects of fluorides on the growth, yield, quality, and appearance of marketable goods such as fruit, grains, leafy vegetables, pine trees, ornamental plants, and dairy cattle.

In determining that there is a need to control fluoride emissions into the atmosphere, the Administrator relied heavily upon the report Fluorides, which was prepared for the Agency by

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[5/] National Academy of Sciences, Fluorides, prepared for EPA under Contract No. CPA 70-42, Washington, D. C. 20418, 1971.

the National Academy of Sciences in 1971. In preparing this report, the Academy made a concerted effort to evaluate the world literature on the subject and distill the best scientific knowledge available on the biological effects of fluorides. This report concludes: "Current knowledge indicates that airborne fluoride presents no direct hazard to man, except in industrial exposure. However, through the commercial, aesthetic, and ecologic functions of plants, fluoride in the environment may indirectly influence man's health and well being." After considering the available information on fluorides, the Administrator has concluded that, even though present evidence indicates that fluorides in the range of ambient concentrations encountered under worst conditions do not damage human health through inhalation, they do present a serious risk to public welfare[6/] and warrant control. Fluoride emissions affect public welfare not only through their effects on aesthetic values, but also through a decrease in the economic value of crops which are damaged by exposure to fluorides and through adverse effects on the health of animals ingesting vegetation which has accumulated excessive amounts of fluorides.

[6/] As used in the Clean Air Act, the term "effects on welfare" includes, but is not limited to, ". . . effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well being." [See section 302(h) 42 U.S.C. 1857h(h) as amended.]

Private citizens and citizens' groups have actively sought means to alleviate fluoride damage. One citizens' group, Center for Science in the Public Interest, has written the Agency describing at great length the need for fluoride regulations. A number of lawsuits have been initiated which are concerned with fluoride effects on agricultural products, and at least 20 citizens' suits have been filed against aluminum plants that emit fluorides.

The Administrator's decision to control fluoride emissions at the national level was based on the following:

1. The present national ambient air quality standards for particulate matter, standing alone, would not provide adequate welfare protection against the effects of fluoride for two reasons: (a) fluorides are emitted as both particulate matter and gases, and (b) since the ambient standard is for "non-specific" particulate matter, compliance with that standard would not ensure fluoride concentrations sufficiently low to prevent damage.
2. Although many states have adopted fluoride control regulations, major sources of fluoride emissions exist in several states with no fluoride regulations.
3. A uniform national standard of performance for new sources would discourage movement of major fluoride emitters to states with no fluoride regulations.

4. Primary aluminum reduction plants, one of the major sources of fluoride emissions, are commonly located near major waterways that comprise borders between states. The potential for interstate conflict concerning control of emissions from such plants has prompted Federal investigations in the past, and in at least one case a state has requested initiation of abatement conference proceedings under section 115 of the Act [42 U.S.C. 1857d].

An EPA report entitled "Preferred Standards Path Report for Fluorides" (November 1972) contains a detailed discussion of the advantages and disadvantages of each regulatory option provided to the Administrator under the Act to control fluoride emissions on a national level.[7] In general, the Administrator concluded that fluorides should be regulated under section 111 of the Act for the following reasons:

1. In contrast with the problems presented by the six pollutants for which national ambient air quality standards have been promulgated, the fluoride problem is highly localized in the vicinity of major point sources in agricultural areas and is not complicated by the presence of numerous mobile sources. Promulgating a national ambient air quality standard for fluorides

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[7] A copy of this report is available for inspection during normal business hours at the Freedom of Information Center, Environmental Protection Agency, 401 M Street, S.W., Washington, D. C.

under section 109 would require states to submit implementation plans to attain and maintain such standards. Because of the complex problems involved in relating emissions to ambient levels, most plans would include regulations based on best demonstrated control technology. The same result can be accomplished more directly and efficiently through the promulgation of standards of performance.

2. Adopting national standards of performance would be more compatible with existing state regulations than adopting ambient air quality standards.
3. Since accumulation of fluorides during chronic exposure to low-level ambient concentrations may result in fluoride levels detrimental to either vegetation or to the health of animals consuming the vegetation, an ambient standard for fluorides may not in fact ensure prevention of adverse welfare effects.
4. An ambient fluoride standard stringent enough to ensure complete protection against any welfare effects might require closure of major sources of fluoride emissions. A more practical and feasible approach is to minimize fluoride damage through best demonstrated control technology; i.e., by regulating fluoride emissions under section 111.

5. The National Academy of Sciences report indicates that because fluorides present no direct hazard to human health, the provisions of section 112 for controlling fluorides as a hazardous air pollutant could not be used.

Promulgation of the proposed standards of performance for fluorides will affect existing sources as explained in section F of this preface. Of particular note is that states will be required to establish standards for the control of fluorides from existing sources under section 111(d) of the Act. The resulting control may not be as stringent as that required by the standards of performance for new sources. As indicated previously, regulations prescribing procedures for control of existing sources under section 111(d) will be proposed as Subpart B of 40 CFR Part 60.

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BACKGROUND INFORMATION FOR PROPOSED STANDARDS OF PERFORMANCE: PHOSPHATE FERTILIZER INDUSTRY

INTRODUCTION

Selection of Affected Facilities

The phosphate fertilizer industry is totally dependent on phosphate rock as its major raw material. About fifteen major processes are used to process phosphate rock into fertilizers and other products. Six of the major processes have been selected for the current program. Others are planned for inclusion in future programs.

Figure 1 shows the large number of fertilizer products and chemicals produced from phosphate rock. After preparation, the rock is used directly in the production of phosphoric acid, normal superphosphate, triple superphosphate, nitrophosphate, electric furnace phosphorus and defluorinated animal feed supplements. Phosphoric acid is an intermediate material, since it is subsequently consumed in the production of superphosphates, ammonium phosphates, complex fertilizers, superphosphoric acid and dicalcium phosphate.

EPA has conducted an extensive study of the industry, including a testing program to develop standards of performance for emissions from the following facilities, which are areas of major growth or are major sources of emissions.

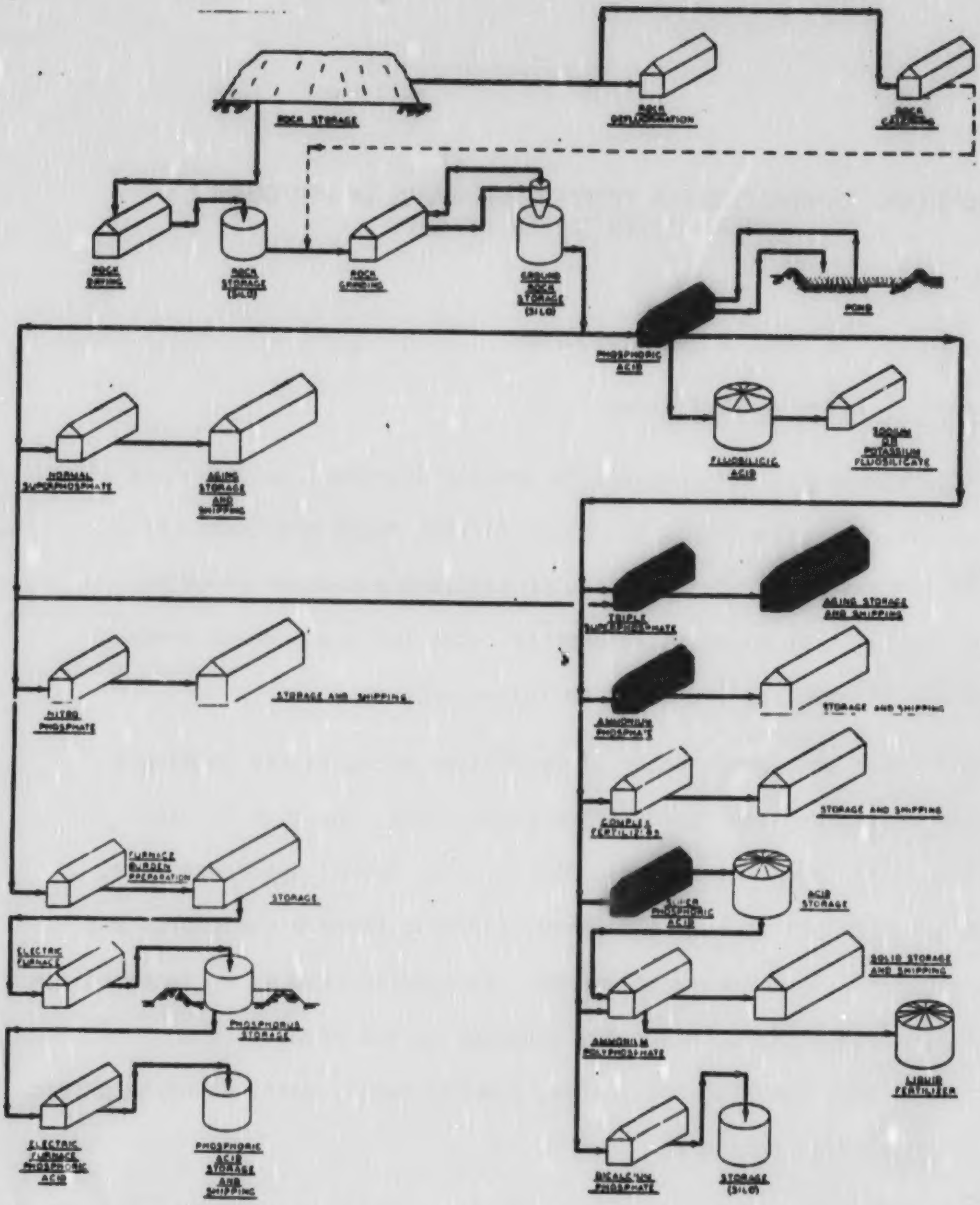
ROCK STORAGE
ROCK DEFLUORINATION
ROCK CALCINING
ROCK DRYING
ROCK STORAGE (SILO)
ROCK GRINDING
GROUND ROCK STORAGE (SILO)
POND
PHOSPHORIC ACID
FLUOSILICIC ACID
SODIUM OR POTASSIUM FLUOSILICATE
NORMAL SUPERPHOSPHATE
AGING STORAGE AND SHIPPING
TRIPLE SUPERPHOSPHATE
AGING STORAGE AND SHIPPING
NITRO PHOSPHATE
STORAGE AND SHIPPING
AMMONIUM PHOSPHATE
STORAGE AND SHIPPING
COMPLEX FERTILIZERS
STORAGE AND SHIPPING
FURNACE BURDEN PREPARATION
STORAGE
SUPER PHOSPHORIC ACID
ACID STORAGE
ELECTRIC FURNACE
PHOSPHORUS STORAGE
SOLID STORAGE AND SHIPPING
AMMONIUM POLYPHOSPHATE
LIQUID FERTILIZER
ELECTRIC FURNACE PHOSPHORIC ACID
PHOSPHORIC ACID STORAGE AND SHIPPING
DICALCIUM PHOSPHATE
STORAGE (SILO)

FIGURE 1
PHOSPHATE ROCK PROCESSING INDUSTRY

1. Wet-process phosphoric acid
2. Superphosphoric acid
3. Diammonium phosphate
4. Run-of-pile triple superphosphate (production and storage)
5. Granular triple superphosphate production
6. Granular triple superphosphate storage

These processes are indicated by the shaded buildings shown in Figure 1. In selecting the six areas for which standards were to be developed, primary considerations were the growth potential of each process and the environmental impact of a standard. Recent articles in the literature indicate that production by these processes will increase by as much as 20 percent over the next 2 years.[2,3,4] Table 1 shows projected growth for wet-process phosphoric acid, ammonium phosphates, and triple superphosphates of about 70, 90, and 20 percent, respectively, over the decade of the seventies.[1] The environmental impact of these processes is significant as evidenced by the estimated fluoride emissions shown. Superphosphoric acid was selected because of its tremendous growth potential (150 percent between 1970 and 1980), even though its collective environmental impact is not estimated to be as great as that of some of the other processes.

A potential source of large quantities of gaseous fluoride emissions is ponds used as cooling and settling basins for process waters. Water from these basins, commonly called gypsum ponds, is used to scrub fluorides out of exit-gas streams from each phosphate fertilizer process. The fluoride content of this gypsum pond water ranges from 5,000 to 10,000 parts per million, and the pond itself appears to be a major source of fluoride emissions.

TABLE 1.

ANNUAL PRODUCTION, EMISSIONS, AND GROWTH RATES

PROCESS	PRODUCTION MILLION TONS P_2O_5/YEAR		TOTAL 1970 FLUORIDE EMISSIONS TONS/YEAR	ANTICIPATED GROWTH PERCENT (1)
	1970	1980		
WET-PROCESS PHOSPHORIC ACID	4.4	7.5	90-100	70
SUPERPHOSPHORIC ACID	0.4	1.0	20- 35	150
DIAMMONIUM PHOSPHATE	2.4	4.6	100-110	92
TRIPLE SUPERPHOSPHATES	1.4	1.7	300-330	21

(1) FOR PERIOD 1970-1980.

Approximations of these emissions range from 0.16 to 5.0 pounds per acre per day,[9,10] which for a typical 200 acre pond is 32 to 1000 pounds of fluoride per day. There is no suitable technique to measure fluoride emissions from gypsum ponds, but the Environmental Protection Agency is now funding a research project at North Carolina State University to study emissions from these ponds. This background information may permit preparation of performance standards for gypsum ponds at a later date.

Selection of Pollutants for Control

In assessing the environmental impact of each of the processes for which standards are now being proposed, the quantity and toxicity of emitted pollutants were considered. Laboratory analyses performed on samples of feedstocks, products, byproducts, and scrubbing liquid did not indicate significant amounts of heavy metals such as mercury, beryllium, cadmium, arsenic, etc. However, significant quantities of fluoride were found in all of the samples. Documented evidence shows that fluorides emitted by phosphate fertilizer plants are responsible for damage to commercially grown flowers, fruits, and vegetables.[5,6,7,23,24] Low concentrations of fluorides can also be absorbed by grasses and plants and cause fluorosis in animals feeding upon such forage. This disease causes mottling of teeth, affects bone structure, retards growth, and adversely affects general health.[5,7,23,24]

Fluoride is emitted from phosphate fertilizer processes as colorless, gaseous silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF).[8] Also, because of the residual fluoride in the recycled water stream which is used as the scrubbing medium, any mist entrained in the scrubber exhaust would contain fluorides. Essentially all of the fluoride emissions were found to be water-soluble. For this reason, it was originally considered to establish performance standards for water-soluble fluorides only. However, during the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) meeting in February 1973, fluoride standards were discussed for two industrial categories, primary aluminum and phosphate fertilizer. A change from water soluble to total fluorides was recommended by a representative for the primary aluminum industry. He revealed that some "insoluble" fluoride compounds will slowly dissolve if allowed to remain in the water-impinger section of the sample train. Since EPA had not closely controlled the time between capture and filtration of the fluoride samples, the change to total fluorides was made to assure a more accurate data base. Since recalculation on the basis of total fluorides revealed that 80 percent of the data remained unchanged and the greatest change was only three percent, it was not necessary to change the absolute value of the proposed standards.

Selection of Units for the Standards

Units of both concentration and mass were considered for the standard. Concentration units have the advantage of being simple and easy to enforce, and they are a parameter used in the design of air pollution control systems. However, they do not necessarily indicate efficient control of mass emissions for this industry. For a given concentration in the effluent gas stream from a control system, the quantity of emissions will vary directly with the effluent gas volume. Our data revealed that even within the same process, the gas volumes vary significantly. For wet-process phosphoric acid plants, gas volumes from plants producing 375 and 325 tons P_2O_5 per day varied from 47,500 to 295,000 standard cubic feet per ton of P_2O_5, respectively.

A mass standard will encourage industry to minimize the amount of process air used, which could further reduce fluoride emissions. A drawback is that many plants do not weigh the fertilizer product; they do, however, determine quite accurately the weights of raw materials and the P_2O_5 content of the feedstock. Therefore, the best units for the performance standard are "pounds of fluoride per ton of P_2O_5 fed." The same units are used by a State agency for its phosphate fertilizer emission control regulations.

Because water absorption of fluorides is the common control mechanism, the possibility of a single fluoride emission standard was considered for all processes in the industry. This approach, however, proved impractical.

The great variation of fluoride concentrations and gas volumes from each process precludes the selection of a single standard that would represent "best demonstrated control" for all processes. Table 2 shows some of the major differences in emissions from the six processes. Although the final concentration of fluorides is about the same for most of the processes, the volume of emissions varies greatly, not only from process to process but also for the same process operated by different owners. Consequently, the mass emission rates measured as pounds of fluoride per ton of P_2O_5 vary by a factor of 1,000. Obviously, a single performance standard for all processes based on either mass or concentration of fluoride in the emissions would be unsuitable.

TABLE 2.

GAS CHARACTERISTICS IN AND OUT OF THE CONTROL DEVICE

PROCESS	TYPICAL GAS FLOW, (scf/ton P_2O_5)	INLET GAS CONCENTRATION (grF/scf)	EMISSIONS	
			(grF/scf)	lbF/ton P_2O_5
WET-PROCESS PHOSPHORIC ACID	50,000	0.02-0.1	0.001- 0.002	0.01- 0.02
SUPERPHOSPHORIC ACID (VACUUM EVAPORATION PROCESS)	1,500	NO DATA	0.002- 0.003	0.0005- 0.0015
DIAMMONIUM PHOSPHATE	300,000	0.005 (1)	0.001	0.04
RUN-OF-PILE TRIPLE SUPERPHOSPHATE AND ROP-TSP STORAGE	350,000	0.3-0.6	0.003- 0.006	0.2- 0.3
GRANULAR TRIPLE SUPERPHOSPHATE	450,000	0.02	0.001- 0.003	0.05- 0.25
GTSP STORAGE	4-10 (3) 30 (2)	0.001- 0.003	0.0008- 0.001	0.0003- (4) 0.0005

(1) GAS CONCENTRATION INTO PACKED SCRUBBER.

(2) scfm/ton P_2O_5 (stored during tests)
(3) scfm/ton P_2O_5 (building capacity)
(4) LbF/hr per ton P_2O_5 stored

During preliminary plant inspections of each of the six processes, some plants of each type had visible emissions of less than 10 percent opacity. A scrubber that effectively controls gaseous fluorides appears to effectively control particulate fluorides also. Therefore, a separate performance standard for particulates was felt to be unnecessary.

Particularly characteristic of this industry are the interrelationships between air pollution and potential water pollution. Also, solid waste and water pollution problems can be encountered with the production of wet-process phosphoric acid, an intermediate product. Filtered crystals of gypsum, a byproduct, along with impurities such as fluorides, calcium, iron, aluminum, and magnesium compounds, are slurried and pumped to nearby gypsum ponds. The water is continuously recycled both for process use and as the scrubbing medium for the control devices. When heavy rainfall causes the pond to overflow, the overflow is treated with lime to raise the pH to acceptable levels and precipitate fluorides before it is discharged to a receiving body of water.

Selection of Sampling and Analytical Methods

An EPA sampling train was developed to measure fluoride emissions. Samples obtained from the 2-hour isokinetic samples were filtered in the laboratory to permit water-soluble and water-insoluble fluorides to be determined separately. The water-soluble portions were analyzed with the specific ion electrode. The water-insoluble portions were fused with sodium, distilled with sulfuric acid, and then analyzed by the SPADNS-Zirconium Lake Method.

Results of EPA tests generally compared favorably with emission measurements conducted by the owner or operator. Although no single explanation for isolated differences was evident, some of the differences could be due to variations in sampling techniques employed by operators of the various plants that were tested. These operators use a less sophisticated sampling technique than EPA. Their sampling train has no ice bath and the operators sample at the point of average velocity, rather than traversing and sampling isokinetically as required by the EPA procedure. Analytical techniques have been verified by comparative tests. Most EPA and industry results agreed within 10 percent. However, substantially lower values were reported by a State agency (see Table 3).

Selection of Facilities for Source Tests

The phosphate fertilizer industry uses water scrubbers to remove fluoride from their emissions. Figures 2, 3, 4, and 5 show the types of scrubbers commonly installed for air pollution abatement in this industry. [1,8,11] The efficiency of these scrubbers is difficult to ascertain without a source test because there is no known device that continuously monitors gaseous fluorides or particulates in this industry. Since gaseous fluorides are invisible, it is impossible by visual observations to directly judge the effectiveness of the control system for fluoride removal. Particulate

Table 3. INTERLABORATORY COMPARISON OF FLUORIDE ANALYSES

(mg/ml)

Sample Number[(a)]	EPA			Phosphate company	Commercial laboratory	State control agency
	No distillation SIE[(b)]	H_2SO_4 Distillation SIE[(b)]	H_2SO_4 Distillation SPADNS[(c)]	$HClO_4$ Distillation SIE[(b)]	No distillation SIE[(b)]	$HClO_4$ distillation titrametric[(d)]
1	940	815	880	900	860	8.3
2	13.9	13.1	18.3	21.2	14	5.6
3	27	31	27	-	-	10.9
4	-	-	12	-	-	5.3
5	29.5	27.6	29.0	29.6	31	-
6	61	60	61.6	61.6	63	-
7	27	29	21	-	27	-
8	52.4	52	54.9	-	51	-
9	98	88	98.3	92.8	99	-
10	7.2	6.9	8.6	8.8	7.4	-
11	2.7	6.8	4.9	4.2	2.8	-

(a) Water-soluble fluorides collected by EPA train.

(b) Specific Ion Electrode.

(c) SPADNS - Zirconium Lake Analysis.

(d) Modified Willard Winter Method.

emissions can often be estimated by sight observations, and the presence of excessive visible emissions is an indication of poor performance for both particulates and fluorides. The best indicators of efficiency or performance available to the plant operator are scrubber pump discharge pressure and pressure differential through the control device.

The initial screening of best-controlled plants was based on:

1. Emission data submitted by manufacturers,
2. Emission data submitted by States,
3. Recommendations by The Fertilizer Institute, and
4. Conversations with industry representatives.

Over 50 plants in eight States were inspected in this program. During investigation of various plant control devices, we were limited by the same problems as the operator -- inability to appraise control efficiency without a source test. Consequently, best-controlled plants were selected according to the type of control device used, its operating characteristics, and apparent quality of maintenance.

Very few processes employed the best emission control systems. Some that did were not suitable for emission testing, and the data base for the recommended performance standard for each affected facility is thus limited. In all processes, however, control is achieved by removal of fluorides from air with water, an extremely good solvent for fluorides. Fluoride removal by a water medium is thus common to the family of processes and this permits a broader base for the application of engineering judgment than individual consideration of each process alone.

Although only a limited number of affected facilities were sufficiently well controlled to warrant testing, most of those selected used a packed scrubber with the scrubbing liquid sprayed on the packing perpendicular to the direction of gas flow (Figure 2). They had consistently high control efficiencies. The packed scrubber, which appears to represent best demonstrated control technology, can be used by all affected facilities.

Other types of scrubbers used by the industry are shown in Figures 3, 4 and 5. Although fluoride emissions from these were higher than from the packed scrubber, there appears to be no reason why similar levels of control cannot be achieved by these types.

During the test program for the development of standards, the following criteria were used in conducting emission tests of each process:

1. The plant was operating at or above its design rate.
2. The scrubbers appeared to be properly maintained.
3. Where possible, plants were tested which use phosphate rock from different rock deposits.
4. In some cases, emission measurements were conducted on the same scrubbers during summer and winter to determine if scrubber performance changed appreciably.
5. When possible, emission measurements were conducted during process operating conditions that would generate the highest rate of emissions of fluorides.

By employing these five criteria, emission measurements from comparatively few "best-controlled" plants provide a firm data base for the development of performance standards.

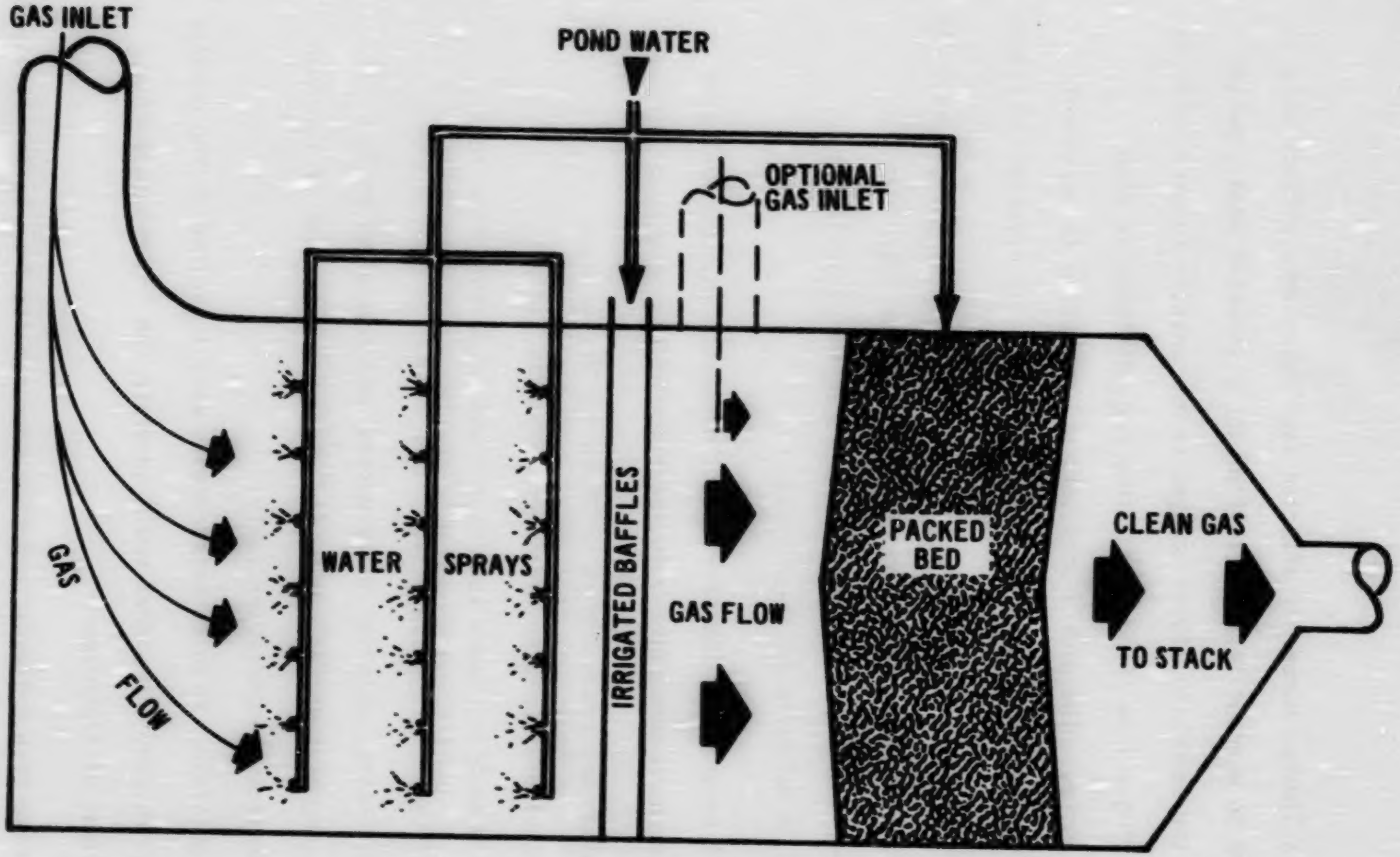
GAS INLET
POND WATER
OPTIONAL GAS INLET
GAS FLOW
WATER
SPRAYS
IRRIGATED BAFFLES
GAS FLOW
PACKED BED
CLEAN GAS
TO STACK

Figure 2.
PACKED SCRUBBER

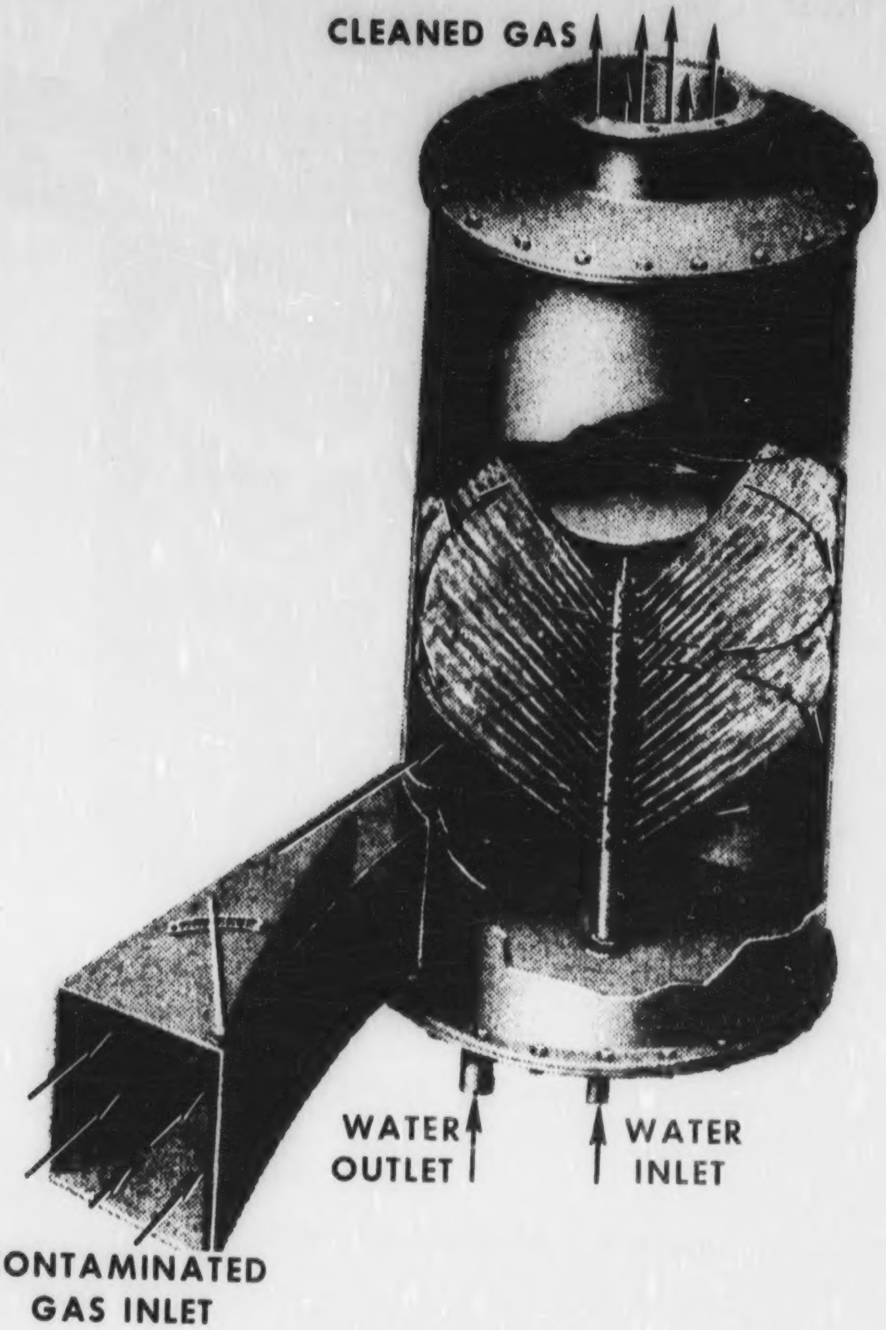
CLEANED GAS
WATER OUTLET
WATER INLET
CONTAMINATED GAS INLET

Figure 3. Cyclonic scrubber.

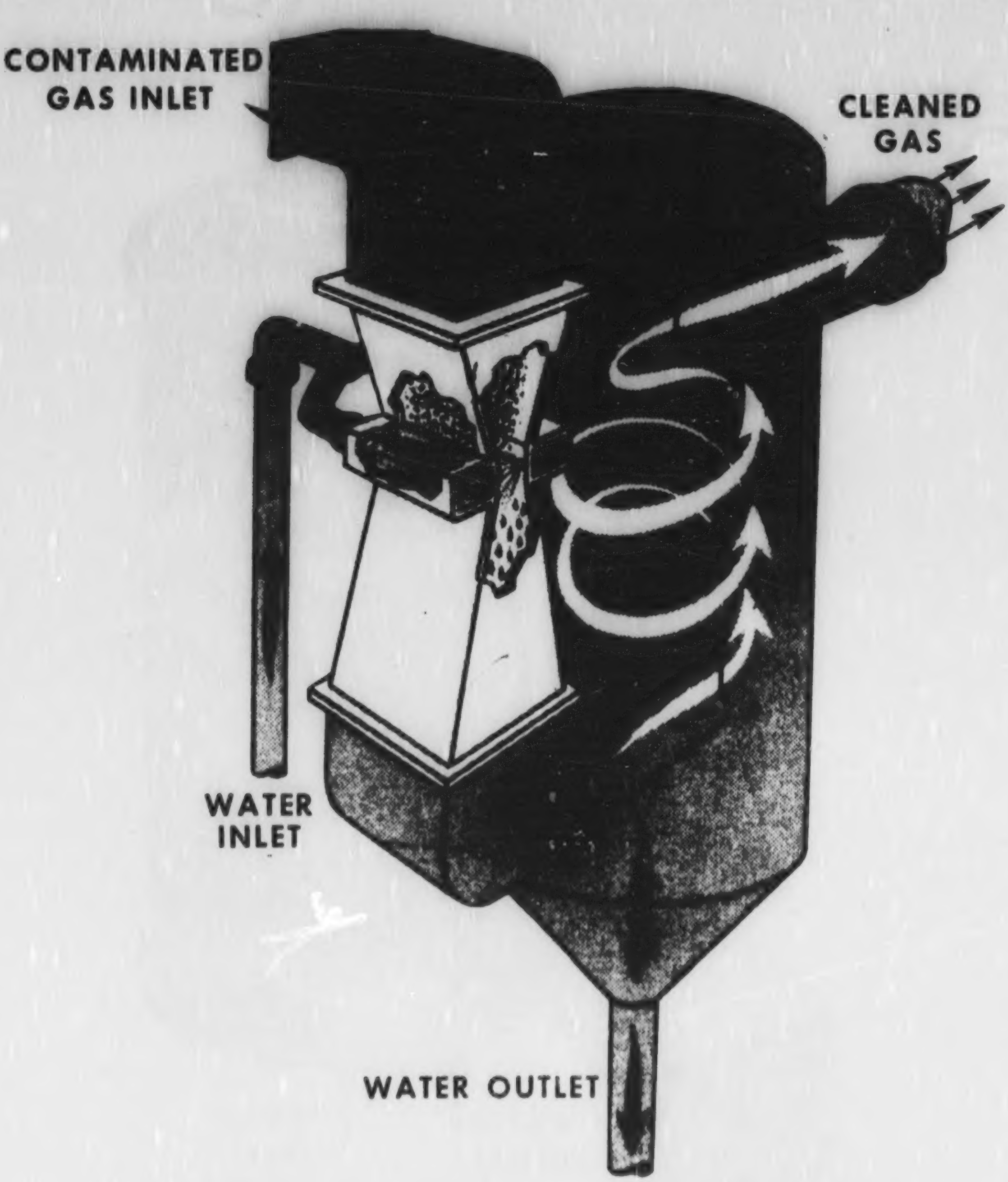
CONTAMINATED GAS INLET
CLEANED GAS
WATER INLET
WATER OUTLET

Figure 4. Air-induced venturi scrubber.

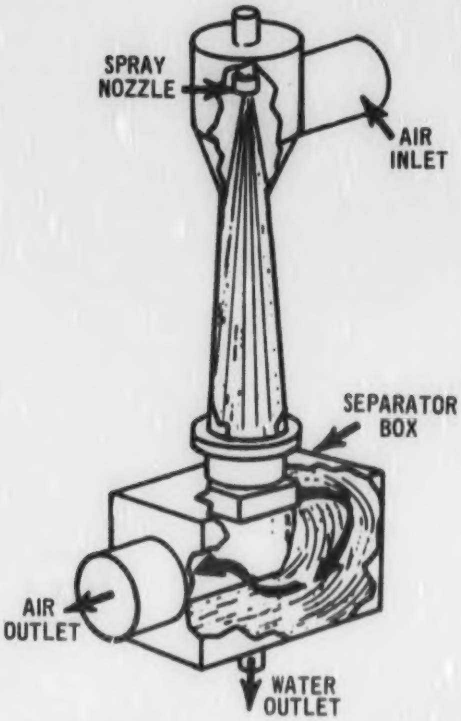
SPRAY NOZZLE
AIR INLET
SEPARATOR BOX
AIR OUTLET
WATER OUTLET

Figure 5. Water-induced venturi scrubber.

WET-PROCESS PHOSPHORIC ACID PLANTS

SUMMARY OF PROPOSED STANDARD

A standard of performance is being proposed for new wet-process phosphoric acid (WPPA) plants. The proposed standard would limit emissions of total fluorides from the wet-process phosphoric acid plant, which is the affected facility. Major sources include but are not limited to the reactor, filter, filtrate seal tanks, barometric condenser hotwells, fluosilicic acid tanks, and clarifier tanks. The standard applies at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized.

The proposed standard would limit emissions to the atmosphere as follows:

Total Fluorides

No more than 10 grams of total fluoride per metric ton of P_2O_5 input to the process (0.02 pounds per ton).

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DESCRIPTION OF PROCESS

The basic reaction is the acidulation of tricalcium phosphate in the phosphate rock. Phosphate rock, sulfuric acid, and water react to produce phosphoric acid and calcium sulfate dihydrate (gypsum).[13] The simplified reaction is:

$$Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O \rightarrow 2H_3PO_4 + 3\,[CaSO_4 \cdot 2H_2O]$$

The production of wet-process phosphoric acid (WPPA) is depicted in the flow diagram shown in Figure 6. The process consists of a reaction step (where rock is acidulated to form phosphoric acid), a filtration step (where the solids are separated from the acid), and an evaporation step (where the acid is concentrated). At the beginning of the process, measured quantities of 93-percent sulfuric acid, weak phosphoric acid (from the filter cake washing process), and pulverized phosphate rock are introduced into a reactor. The highly exothermic reaction is cooled by a vacuum cooler, which also degasifies the slurry of dissolved air, carbon dioxide, and fluorides. After a retention time of 5 to 8 hours, the slurry is pumped to a filter where the acid is separated from the byproduct gypsum. The gypsum is reslurried with effluent process water amd pumped to the gypsum pond. The acid, containing about 30-percent P_2O_5, is concentrated by vacuum evaporators to about 54-percent P_2O_5. The 54-percent P_2O_5 acid is then pumped to product storage tanks.

Some plants recover fluorides as byproduct fluosilicic acid by installing absorption sections on the top of the evaporators immediately upstream from the barometric condensers.[11,13]

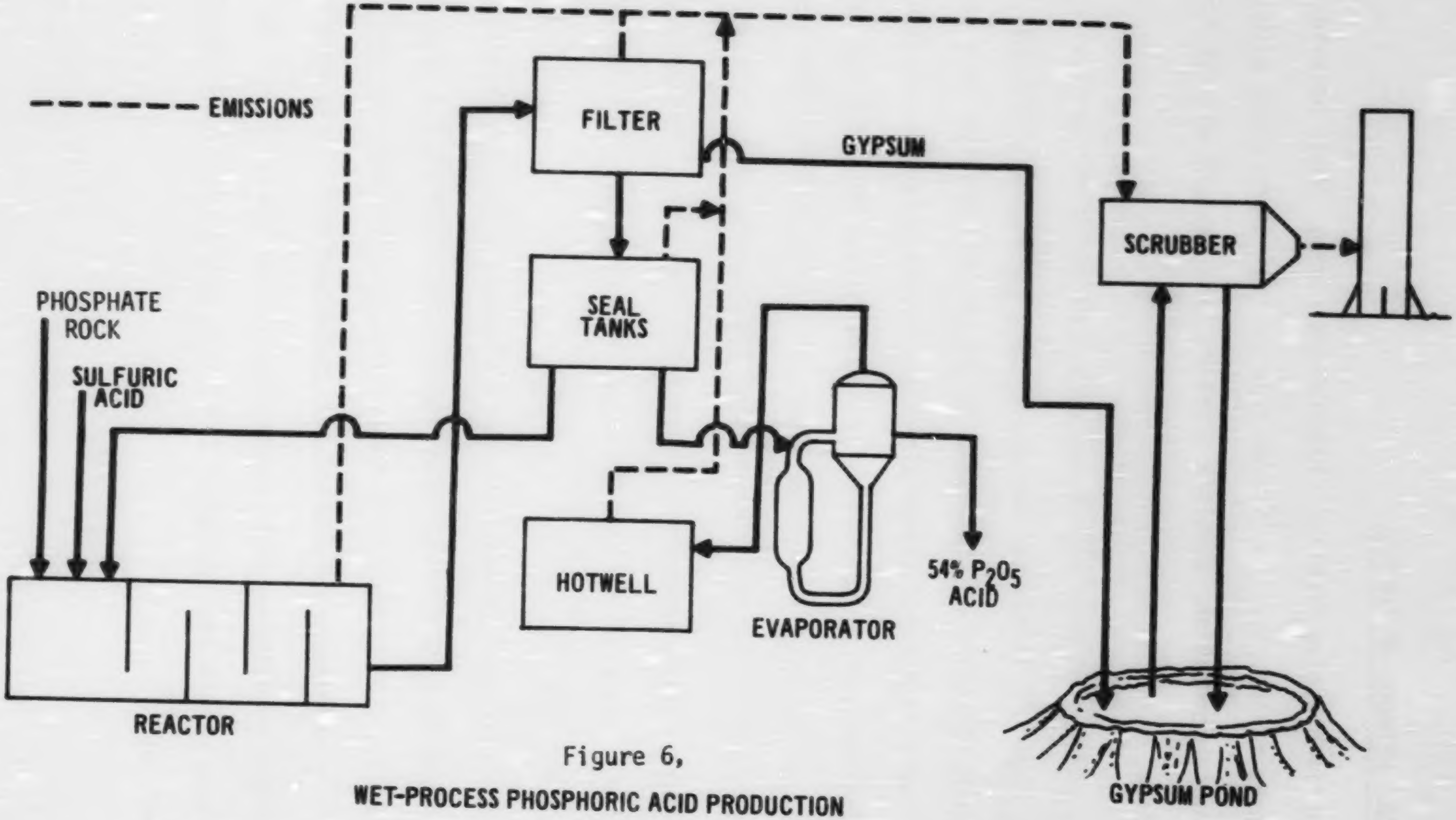

EMISSIONS
PHOSPHATE ROCK
SULFURIC ACID
REACTOR
FILTER
SEAL TANKS
HOTWELL
EVAPORATOR
GYPSUM
$54\%\ P_2O_5$ ACID
SCRUBBER
GYPSUM POND

Figure 6,

WET-PROCESS PHOSPHORIC ACID PRODUCTION

EMISSIONS AND METHODS OF CONTROL

Gaseous fluorides evolve from any fluoride-containing liquid because of the vapor pressure of the fluoride.[15] The rate of evolution varies with temperature, concentration, absolute pressure, and exposed area of the liquid surface.

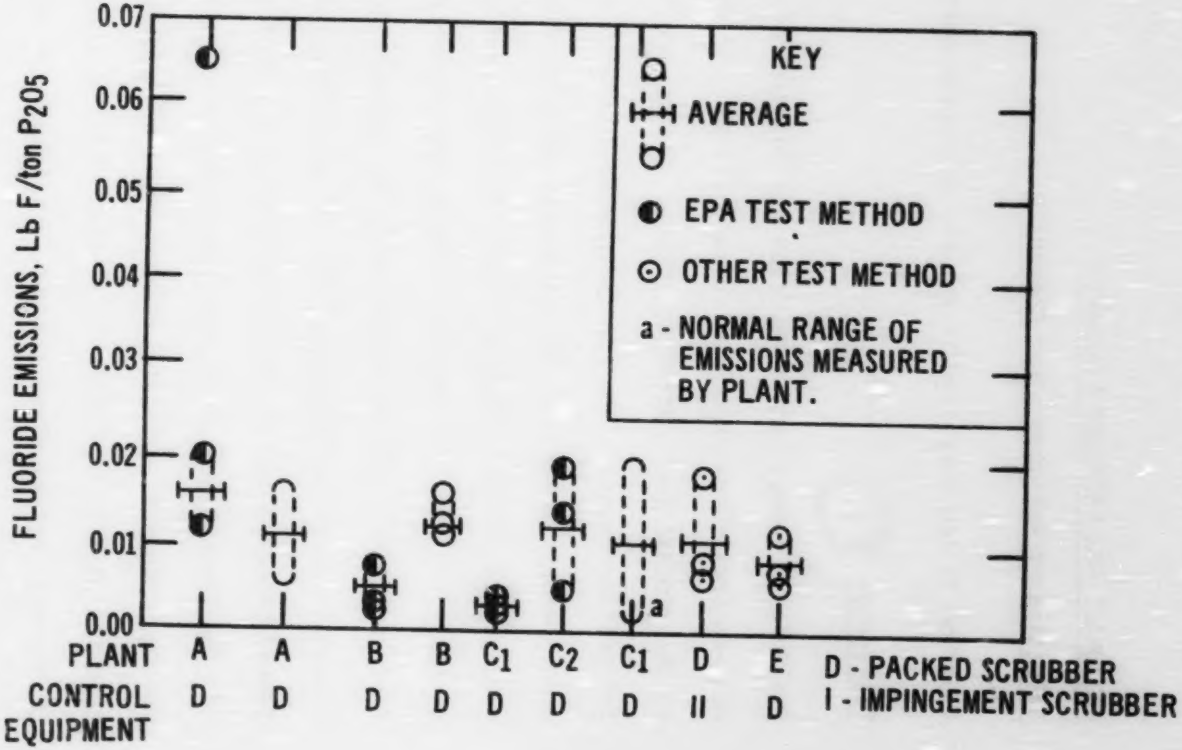
Some poorly controlled WPPA plants can emit 0.07 pound of fluoride per ton of P_2O_5 input.[16] A 500-ton-per-day (TPD) P_2O_5 installation, equipped with such control equipment would emit 35 pounds of fluorides each day of operation. Well-controlled plants which use packed scrubbers or other equally effective control can achieve fluoride emissions below 0.02 pound fluoride per ton of P_2O_5 input (see Figure 7). Such a well-controlled 500-TPD P_2O_5 plant would emit 10 pounds of fluoride per day.

Best demonstrated emission control consists of scrubbing off-gases with pond water in a packed scrubber. These typically achieve 98 to 99 percent removal of fluorides.

Several State and local regulations limit fluoride emissions from wet-process phosphoric acid plants. Some regulations restrict the mass of emissions per unit of production. Others are based on the fluoride content of surrounding vegetation or ambient air concentrations.[1] The most stringent State regulation, 0.02 pound fluoride per ton of P_2O_5 feed to the process, would permit the typical 500-TPD P_2O_5 plant to emit 10 pounds of fluoride per day.[17]

FIGURE 7

FLUORIDE EMISSIONS FROM WET-PROCESS PHOSPHORIC ACID PLANTS



RATIONALE FOR PROPOSED STANDARD

Selection of Pollutants for Control

Fluoride is the only significant air pollutant emitted from WPPA plants.

Discussion

Preliminary investigation revealed the location of several reportedly well-controlled plants. Twelve were visited and information was obtained on the process and control equipment. Seven were not further considered for testing because fluoride fumes were excessive in the processing area (perhaps the result of inadequate maintenance) or the physical arrangement of the equipment (e.g., ductwork configuration) was not suitable for accurate testing. Stack tests were conducted at the remaining five locations. One of these was later tested a second time to see if seasonal variations had any effect on emissions. Results of that test showed higher emissions during warm weather, indicating a possible effect of the temperature of gypsum pond water on the effectiveness of the contnol device. However, similar seasonal tests of emissions from superphosphoric acid and diammonium phosphate plants failed to confirm such an effect. During the initial plant surveys, 12 plants with scrubbers exhibited no visible stack emissions other than uncombined water vapor. Results of one test on Plant A, which measured 0.065 lb/ton of P_2O_5, were not considered during the final evaluation of the data. This figure was unexplainably much higher, not only than any other EPA sample, but also much higher than any results the operator had measured from numerous tests over the previous year. No definite reason for the high number could be identified. The process instrumentation gave no indication of a process upset or scrubber malfunction. Results of the other two samples were 0.011 and 0.019 pound fluoride per ton P_2O_5 input. Results of testing by the operator indicated average fluoride emissions of 0.013 pound fluoride with a range of 0.007 to 0.018 pound fluoride per ton p_2O_5 input.

Results of the tests conducted by EPA reveal emissions from plants with packed scrubbers (Plants A, B, C, and E) averaged 0.015, 0.006, 0.002, 0.012 (retest of Plant C), and 0.011 pound fluoride per ton of p_2O_5 input. Plant D, controlled by an impingement scrubber, averaged 0.008 while ranging from 0.006 to 0.011; however on the average, impingement scrubbers do not perform as well as packed scrubbers for this process.

Concurrent testing by the plant operator indicated average fluoride emissions of 0.014 (Plant B) and 0.010 (Plant C) pound fluoride per ton P_2O_5 input. Individual samples ranged from 0.010 to 0.017 pound.

Tests were conducted by EPA while the plants were operating at or near their design production rates. A complete summary of test results can be found in Volume 2.

The proposed standard of 10 grams of total fluoride per metric ton of P_2O_5 input (0.02 pound per ton) is supported by emissions measured from the plants as presented in Figure 7. The standard will require installation and proper maintenance of equipment representative of the best technology which has been demonstrated for the industry. In the Administrator's judgment, achievability of the proposed standard of 10 grams of total fluoride per metric ton (0.02 lb F/ton P_2O_5) has been adequately demonstrated.

A visible emissions standard is not recommended for WPPA plants. Since there can be no emissions visible even from an uncontrolled WPPA plant, a standard would have little meaning.

SUPERPHOSPHORIC ACID PLANTS

SUMMARY OF PROPOSED STANDARDS

A standard of performance is being proposed for new superphosphoric acid (SPA) plants that manufacture acid for the production of fertilizer. The proposed standard would limit emissions of total fluorides from the superphosphoric acid plant, which is the affected facility. Major sources include but are not limited to evaporators, product cooling tanks, and barometric condenser hotwells. The standard applies at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized. The proposed standard would limit emissions to the atmosphere as follows:

Total Fluorides

No more than 5 grams of total fluorides per ton of P_2O_5 input to the process (1×10^{-2} lb/ton).

DESCRIPTION OF PROCESS

SPA is produced by concentrating 54-percent P_2O_5 phosphoric acid to 70 (±2) percent P_2O_5. Two commercial processes are used for SPA: vacuum evaporation (VE) and submerged combustion (SC).

Production of SPA by vacuum evaporation (VE-SPA) is depicted in Figure 8. Clarified 54-percent P_2O_5 phosphoric acid is continuously fed to a vacuum evaporator. The hot off-gases, which contain water vapor and fluorides, are condensed in the water-cooled barometric condenser. The fluoride-laden condenser water flows to the hotwell where it cools before draining to the gypsum pond. The concentrated acid is continuously drawn from the evaporator to product cooling tanks, where it is cooled before being pumped to storage.

In the submerged combustion (SC-SPA) process, depicted in Figure 9, hot gases are forced below the surface of the 54-percent P_2O_5 phosphoric acid in a submerged

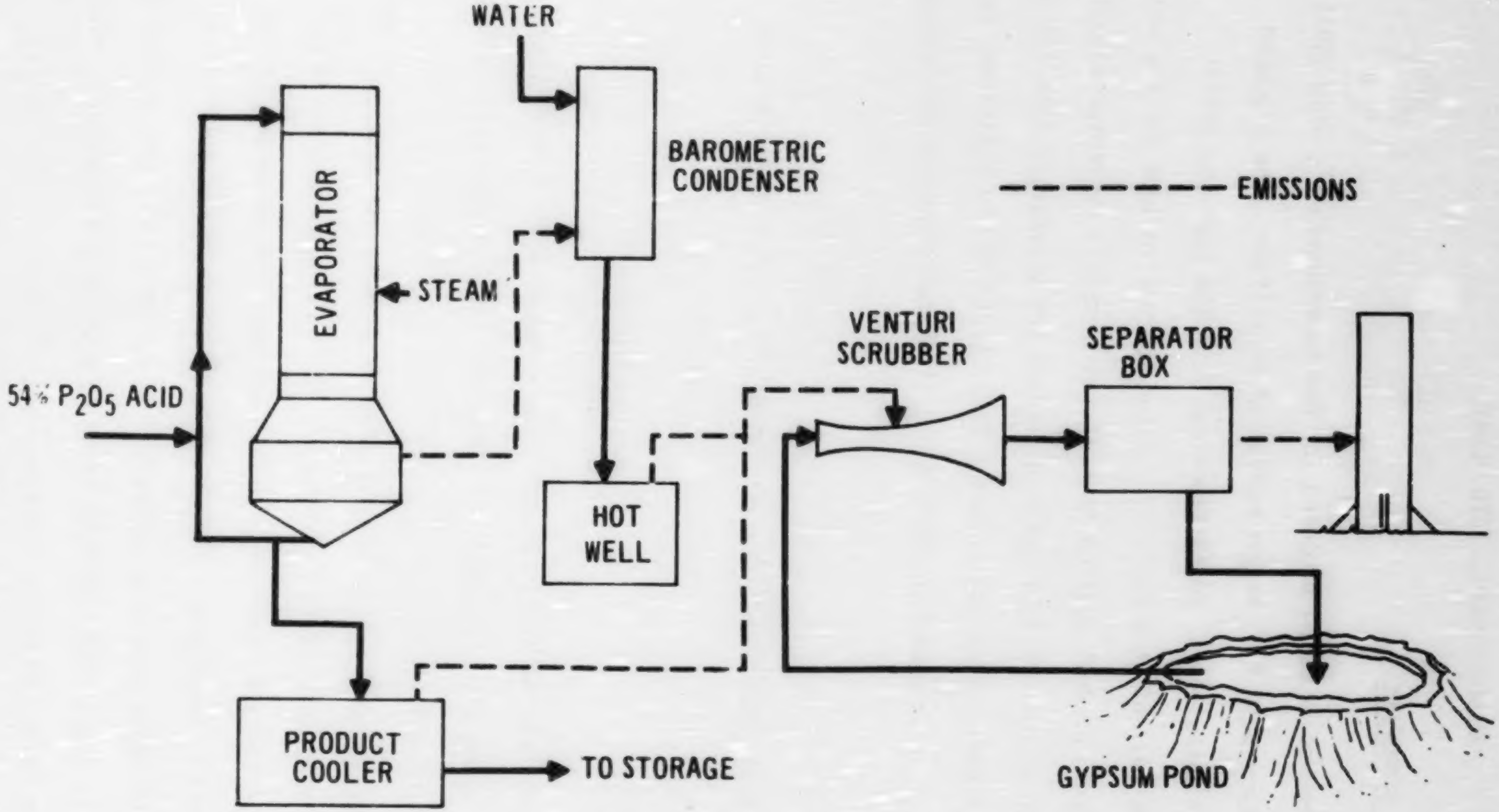

WATER
BAROMETRIC CONDENSER
EMISSIONS
EVAPORATOR
STEAM
54% P_2O_5 ACID
HOT WELL
VENTURI SCRUBBER
SEPARATOR BOX
PRODUCT COOLER
TO STORAGE
GYPSUM POND

Figure 8. VACUUM EVAPORATION SUPERPHOSPHORIC ACID

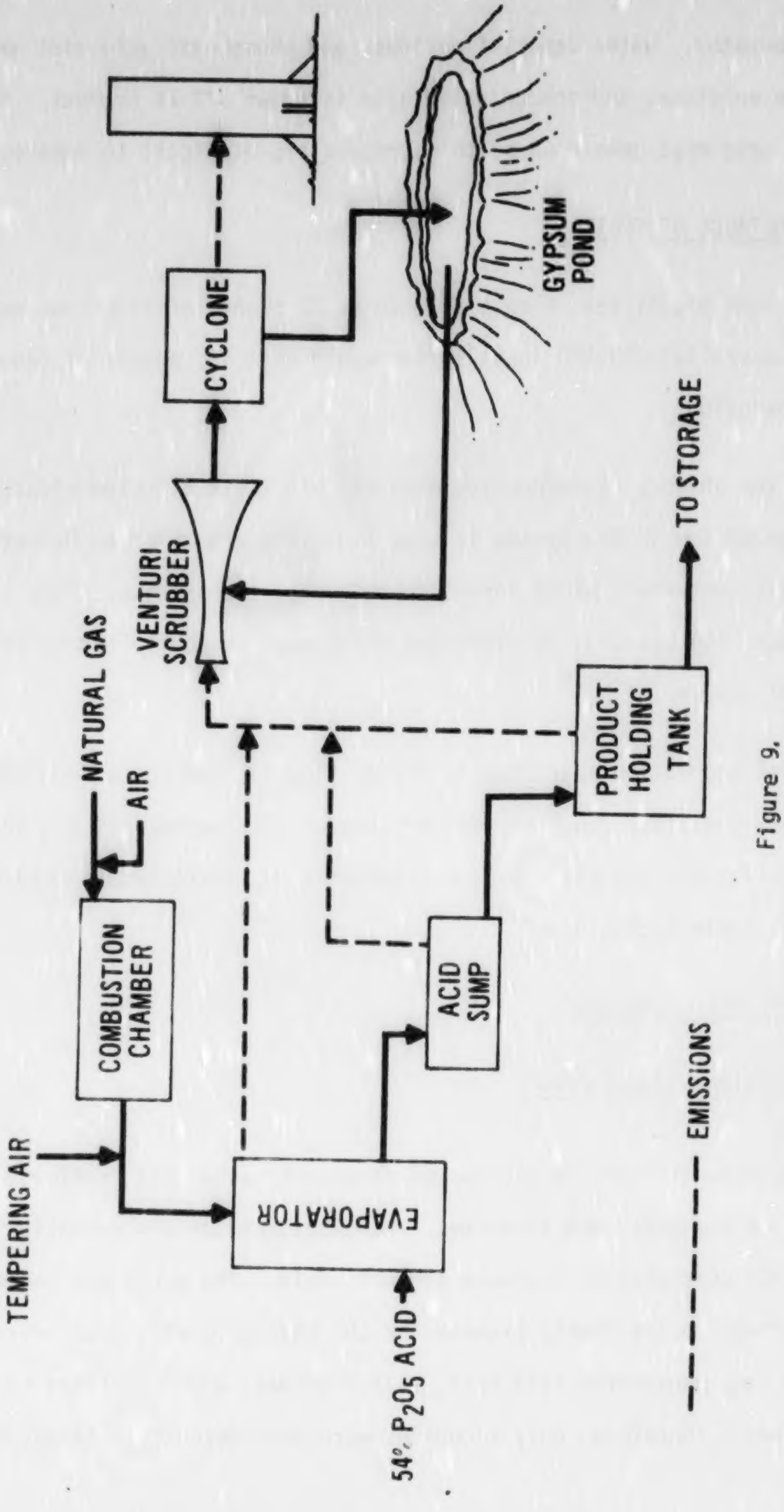

TEMPERING AIR
COMBUSTION CHAMBER
NATURAL GAS
AIR
EVAPORATOR
54% P2O5 ACID
ACID SUMP
PRODUCT HOLDING TANK
TO STORAGE
VENTURI SCRUBBER
CYCLONE
GYPSUM POND
EMISSIONS

Figure 9.

SUBMERGED COMBUSTION SUPERPHOSPHORIC ACID PRODUCTION combustion evaporator. Water vapor, fluorides, and phosphoric acid mist are driven from the solution, and concentrated acid is drawn off as product. Fluorides and phosphoric acid mist generated by this process are difficult to control.[13,19]

EMISSIONS AND METHODS OF CONTROL

Uncontrolled SC-SPA plants can release as much as 22 pounds of fluorides per ton of P_2O_5.[18] An uncontrolled 200-TPD installation would emit 185 pounds of fluoride each hour of operation.

In addition to the absence of combustion products and their dilution effect, a second advantage of the VE-SPA system is that fluorides are absorbed by water in the barometric condenser during normal operation of the process. This significantly reduces the quantity of fluorides which must be controlled by the emission control device.[13,18,19]

No State or local regulation specifically limits fluoride emissions from SPA plants. However, one State requires that any source of fluorides (i.e., SPA plants) not specifically regulated by the State will be controlled in accordance with "latest available technology."[17]

RATIONALE FOR PROPOSED STANDARD

Selection of Pollutants for Control

The potential pollutants from SPA plants are phosphoric acid mist, sulfur oxides, combustion products, and fluorides. Manufacturers of SPA normally control phosphoric acid mist to increase product yield. The equipment necessary to control fluorides to the limits proposed by the standards will also provide some control for any phosphoric acid mist, sulfur oxides, and combustion products not now controlled. Therefore, only fluorides were considered for standards development.

Discussion

No SC-SPA plants were tested by EPA in the development of the proposed standards for several reasons: 1) no well-controlled plants were observed; 2) the majority of members of the phosphate fertilizer industry consider submerged combustion an outdated process and future growth unlikely; and 3) the Act makes clear that new plants should utilize processes which have the least environmental impact.

Two seemingly well-controlled VE-SPA plants were located. One produces a specialized SPA used as an intermediate for the production of animal feed. This process is designed to steam-strip fluorides from the acid to minimize the possible effect on animals that consume the feed. As might be expected, this results in high evolution of fluorides from the process. The average for the test by EPA was 0.02 lb F/ton of P_2O_5 input with a range of 0.015 to 0.024. This average is 20 to 40 times greater than that measured from a similar plant which produces SPA as an intermediate for the fertilizer industry and consequently does not purposely strip fluorides. Because the process associated with animal feed is distinctly different from the majority of SPA plants which produce an intermediate for the fertilizer industry, it was decided to recommend that the standard not apply to those facilities that prepare animal feed. (In the event a single plant manufactures for both markets, it will be subject to the standard when producing a fertilizer intermediate.) Consequently, the data from this first plant test were not used in the development of the performance standard.

The second well-controlled plant, which does produce SPA for the fertilizer industry, was tested by EPA in the early winter of 1971 and again in the summer of 1972.

Results of the two tests (three samples per test) conducted by EPA (Figure 10) reveal emissions from Plant A average 9×10^{-4} and 4.6×10^{-4} pound of fluoride per ton of P_2O_5 respectively. Individual sample results ranged from 4.1×10^{-4} to 15×10^{-4} lb F/ton P_2O_5.

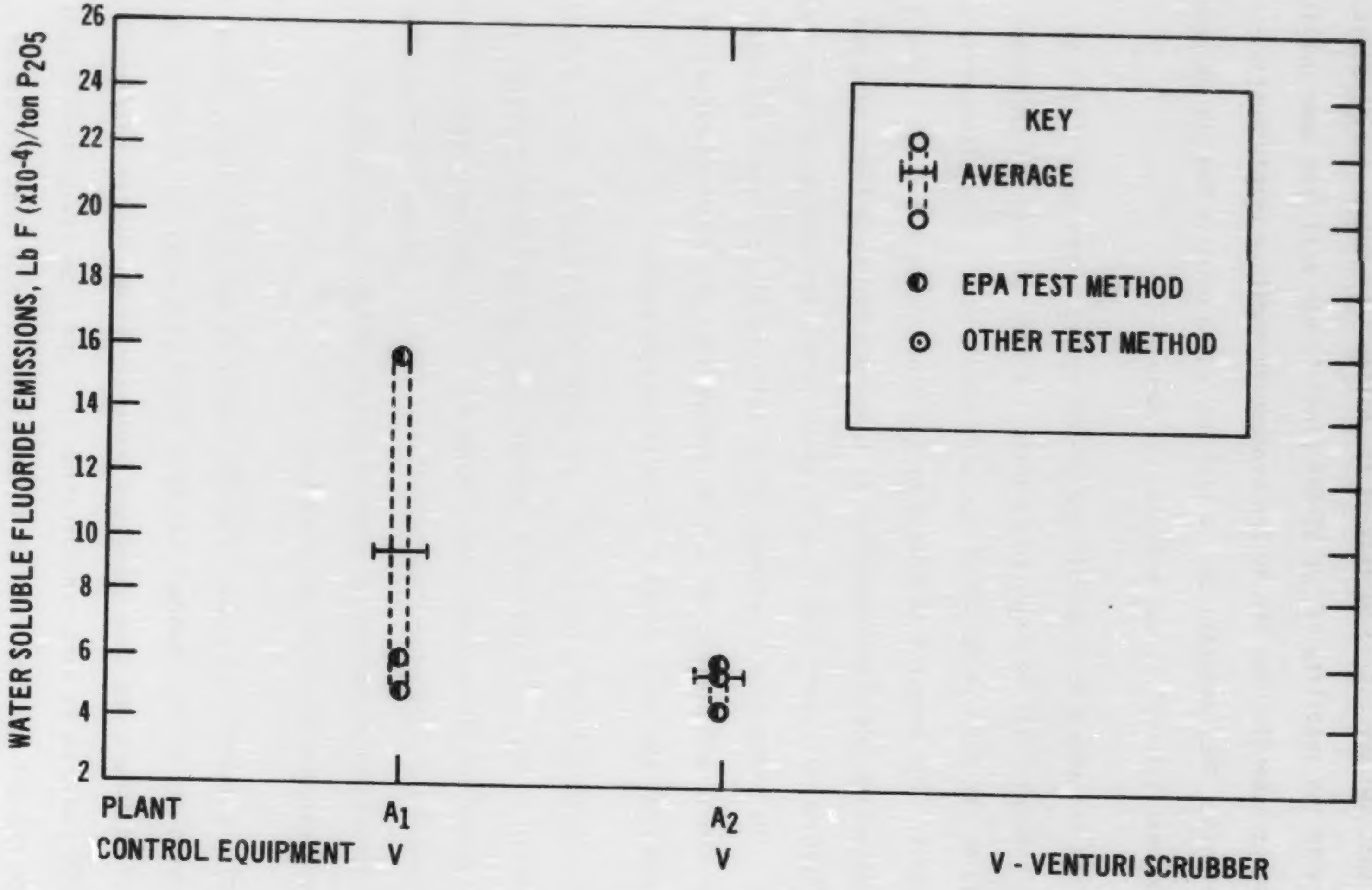
Tests were conducted by EPA while the plant was operating at or near its design production rate. A complete summary of test results can be found in Volume 2.

During the initial plant surveys, none of the VE-SPA plants exhibited visible stack emissions other than uncombined water vapor.

Based on the emission test data from the VE-SPA plants, EPA originally considered proposing a standard of 1 gram of fluoride per metric ton of P_2O_5 input (2×10^{-3} lb/ton). The inherently low uncontrolled emissions from this process made it obvious that the SC-SPA process could not be economically controlled to the same level. This would probably preclude any future construction of the SC-SPA process and, at that time this action seemed justifiable since inherent characteristics of the SC-SPA process render it significantly more polluting than the VE-SPA process. Furthermore, as stated previously, representatives of the industry indicated that the SC-SPA process was near obsolete and would not be built regardless of any subsequent air pollution standard. When the standard was presented at the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) meeting, it became obvious that two companies consider the SC-SPA process the more desirable. In fact, they

FIGURE 10

FLUORIDE EMISSIONS FROM SUPERPHOSPHORIC ACID PLANTS



contend that the decreasing quality of the nation's phosphate rock reserves coupled with the inability of the VE-SPA plant to use acid from poor quality rock make it essential for the SC-SPA process to remain a viable option for future plants. They maintain that a standard which permits the SC-SPA process is in the best interest of our national resources.

In altering the standard to permit the SC-SPA process, the result is that VE-SPA plants will not be required to install a control device. Separate standards for VE-SPA and SC-SPA plants were considered. This alternative has little merit. The original objective of the fluoride standard was to indirectly force prospective SPA plant operators to construct the VE-SPA process, not to reduce fluoride emissions from VE-SPA plants (which are only about four pounds per day). The standard now recommended is sufficiently stringent to still encourage the VE-SPA process but can be achieved by other SPA processes if they install the best available systems of emission reduction.

No SC-SPA plants utilize a packed scrubber with the scrubbing liquid introduced perpendicular to the gas flow. This scrubber was proven most efficient in controlling air pollution from other phosphate fertilizer processes. Consequently, the standard for SC-SPA plants was calculated based on emission information obtained from these scrubbers on other processes which have repeatedly achieved exit concentrations of three ppm fluorides.

The fluoride standard proposed for SPA plants is now 0.01 lb per ton of P_2O_5. The achievability of the standard has been indirectly endorsed by three designers of control equipment who have submitted proposals to one SC-SPA operator. The standard is based on an exit concentration of 3 ppm from the control device and an average exhaust gas flow rate of 47,000 standard cubic feet per ton of P_2O_5. The achievability of this exit concentration is supported by the following:

a. The average fluoride concentration measured by EPA from packed scrubbers controlling wet-process phosphoric acid plants, diammonium phosphate plants, granular triple superphosphate plants and granular triple superphosphate storage buildings was three ppm.

b. One designer of a packed scrubber reported that an exit concentration of three ppm fluorides can always be achieved and that they are designed to achieve 1.5-2 ppm.

Data supplied by a major operator of an SC-SPA plant indicate that gases exit his plant at a rate of 47,000 standard cubic feet per ton of P_2O_5. The exit concentration of 11,000 ppm by volume is reduced to 50 ppm with the existing control system.

To verify the practicality of a standard which is essentially equivalent to 3 ppm (although higher concentrations are permissable if the volume of exhaust gas is reduced), conventional design criteria were used to estimate the efficiency (measured in terms of transfer units) which would be required of a control device.

The number of transfer units necessary to achieve three ppm was calculated as follows. The calculation assumes that the concentration of fluorine in the scrubbing liquid is constant through the scrubber, a valid assumption because of its relatively high concentration in the inlet liquid. The number of transfer units required to scrub a lean gaseous effluent is defined by:[8]

$$N_{OG} = \ln \frac{Y_1 - Y_a}{Y_2 - Y_a}$$

Where:

N_{OG} = number of transfer units

Y_1 = fluoride concentration in the inlet gas phase (11,000 ppm)

Y_2 = fluoride concentration in the outlet gas phase (3 ppm)

Y_a = fluoride concentration in the gas phase in equilibrium with the scrubbing liquor (1.5 ppm, based on equilibrium vapor pressure data for gypsum pond water)[25] and other sources.[26]

Using these criteria, N_{OG} is calculated as 8.9 transfer units. If a packed scrubber is installed downstream of an existing control device which achieves 50 ppm, then only 3.5 transfer units are required of the packed scrubber.

Packed scrubbers now operating at other phosphate fertilizer processes commonly achieve three to four transfer units. Therefore, a scrubber of about the same efficiency would be needed to supplement typical existing control at SC-SPA plants.

It is possible that other acid gases such as SO_x may adversely influence the absorption efficiency and require slightly more transfer units than the above calculations would indicate. Also, the presence of acid mists may require the installation of a mist eliminator or some other particulate collection device, such as a venturi scrubber. Even if this additional control is needed, the cost of control is not prohibitive (0.13 percent of the sales price of SPA as reported in the economic report following the technical reports) and in the Administrator's judgment, the achievability of the proposed standard has been adequately demonstrated.

Since no existing SC-SPA plant now operating has a control device which can be considered best technology, we are unable to obtain visible emission data. Consequently, no visibility standard will be recommended at this time for the SPA process.

DIAMMONIUM PHOSPHATE PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new diammonium phosphate (DAP) plants. The proposed standards would limit emissions of total fluorides and visible emissions from the diammonium phosphate plant, which is the affected facility. Major sources include but are not limited to the reactor, granulator, dryer, cooler, screens, and mills. The standards apply at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized.

The proposed standards would limit emissions to the atmosphere as follows:

Total Fluorides

No more than 30 grams fluoride per metric ton of P_2O_5 input to the process for new diammonium phosphate plants (0.06 pound per ton).

Visible Emissions

Visible emissions shall be less than 20 percent opacity.

DESCRIPTION OF PROCESS

The process consists of a prereactor, a reactor-granulator, and accessory equipment for drying, cooling, and screening the product (Figure 11).[19] The primary reaction is: $2\ NH_3 + H_3PO_4 \rightarrow (NH_4)_2\ HPO_4$.

Unreacted ammonia gas which is not absorbed by the rock is carried from the prereactor and granulator with the exhaust gas. Most of the ammonia is recovered by scrubbing the exhaust gas with a weak (20 to 30 percent P_2O_5) phosphoric acid solution.

The DAP slurry in the reactor is pumped to the granulator where additional ammonia and recycled product are added to form a solid material which averages 18 percent nitrogen and 46 percent P_2O_5. It is then dried, cooled, and screened before being conveyed to storage.

EMISSIONS AND METHODS OF CONTROL

Considerable quantities of fluorides can be stripped from the scrubbing medium, dilute phosphoric acid which contains fluorides. This source of fluorides is particularly significant when a higher concentration acid (30 to 40 percent P_2O_5) is used. Fluorides are also present in any mist entrained from the scrubbers or in solid particulates carried from both the granulator and dryer.

Poorly controlled diammonium phosphate plants can release un to 0.5 pound of fluoride to the atmosphere per ton of P_2O_5 input.[1] A 500-TPD

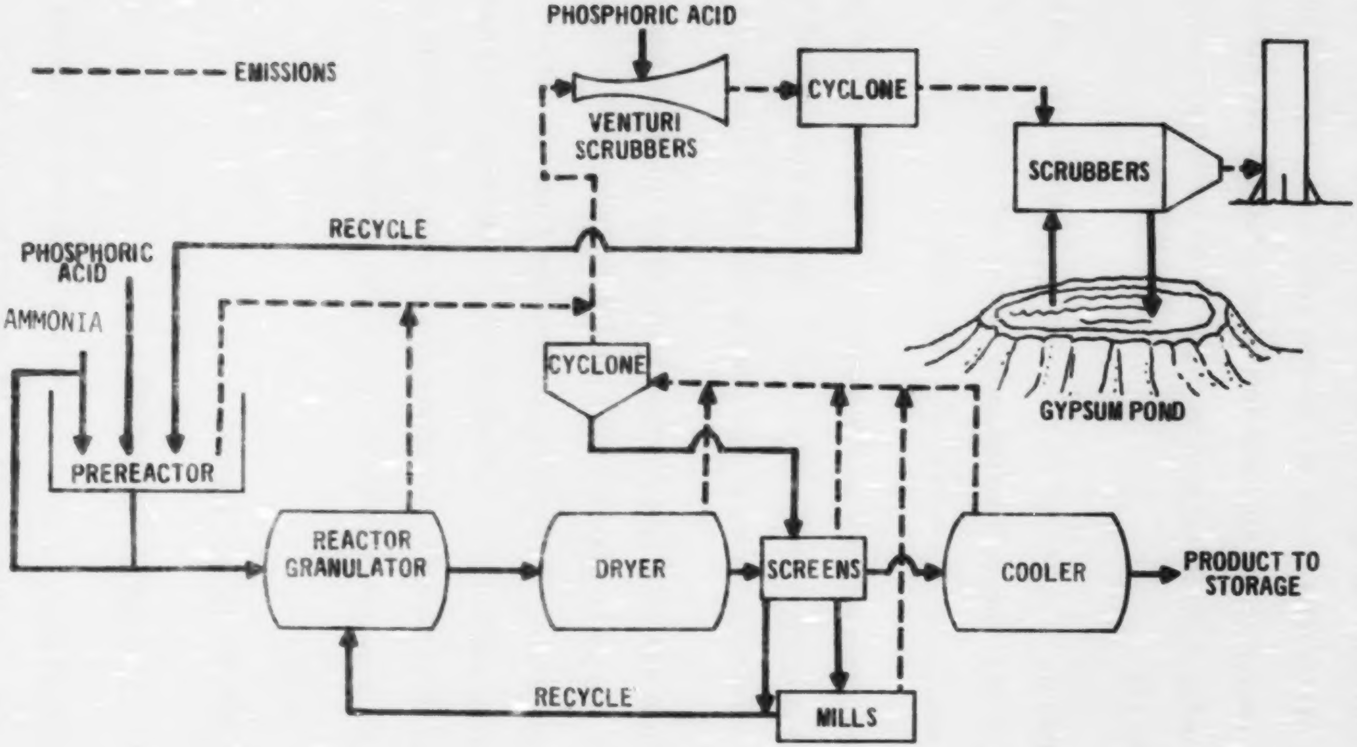

EMISSIONS
PHOSPHORIC ACID
VENTURI SCRUBBERS
CYCLONE
SCRUBBERS
RECYCLE
PHOSPHORIC ACID
AMMONIA
CYCLONE
GYPSUM POND
PREREACTOR
REACTOR GRANULATOR
DRYER
SCREENS
COOLER
PRODUCT TO STORAGE
RECYCLE
MILLS

Figure 11. DIAMMONIUM PHOSPHATE PRODUCTION

P_2O_5 installation, equipped with such control equipment, would emit 250 pounds of fluorides each day of operation. Well-controlled DAP plants employing primary and secondary scrubbers can achieve fluoride emissions below 0.06 lb F/ton P_2O_5 input or 30 pounds of fluoride per day (see Figure 12).

Although ammonia is a potential pollutant from diammonium phosphate plants, the industry has long maintained good control of ammonia, a major raw material, because of its relatively high cost.

The best demonstrated control for ammonia consists of scrubbing emissions with a weak phosphoric acid solution. Fluorides are removed by secondary scrubbing with packed scrubbers.

Several State and local regulations limit fluoride emissions from diammonium phosphate plants. Some restrict the mass of emissions per unit of production. Others are based on the fluoride content of surrounding vegetation or ambient air concentrations.[1] The most stringent State regulation, 0.06 pound fluoride per ton of P_2O_5 feed to the process, would permit the typical 500-TPD P_2O_5 plant to emit 30 pounds of fluoride per day.[17]

RATIONALE FOR PROPOSED STANDARDS

Selection of Pollutants for Control

Ammonia, fluorides, and particulates are potential pollutants from this process. The low concentrations of ammonia measured during this program (1 ppm) verified that operators are very effectively recovering ammonia.

Combustion products from the drying operation are present in the stack gases, but in very minor concentrations. Therefore, only fluorides and particulates were considered for standards development.

Discussion

Preliminary investigations revealed the locations of several reportedly well-controlled plants. Nine were visited and information was obtained on the process and control equipment. Six were not further considered for testing because either fluoride fumes were excessive in the processing area (perhaps the result of inadequate maintenance) or the equipment (e.g., ductwork configuration) was not suitable for accurate testing. One of these (Plant B) was modified to accommodate an EPA test in March of 1973. Stack tests were conducted at the remaining locations. Plant A was tested twice.

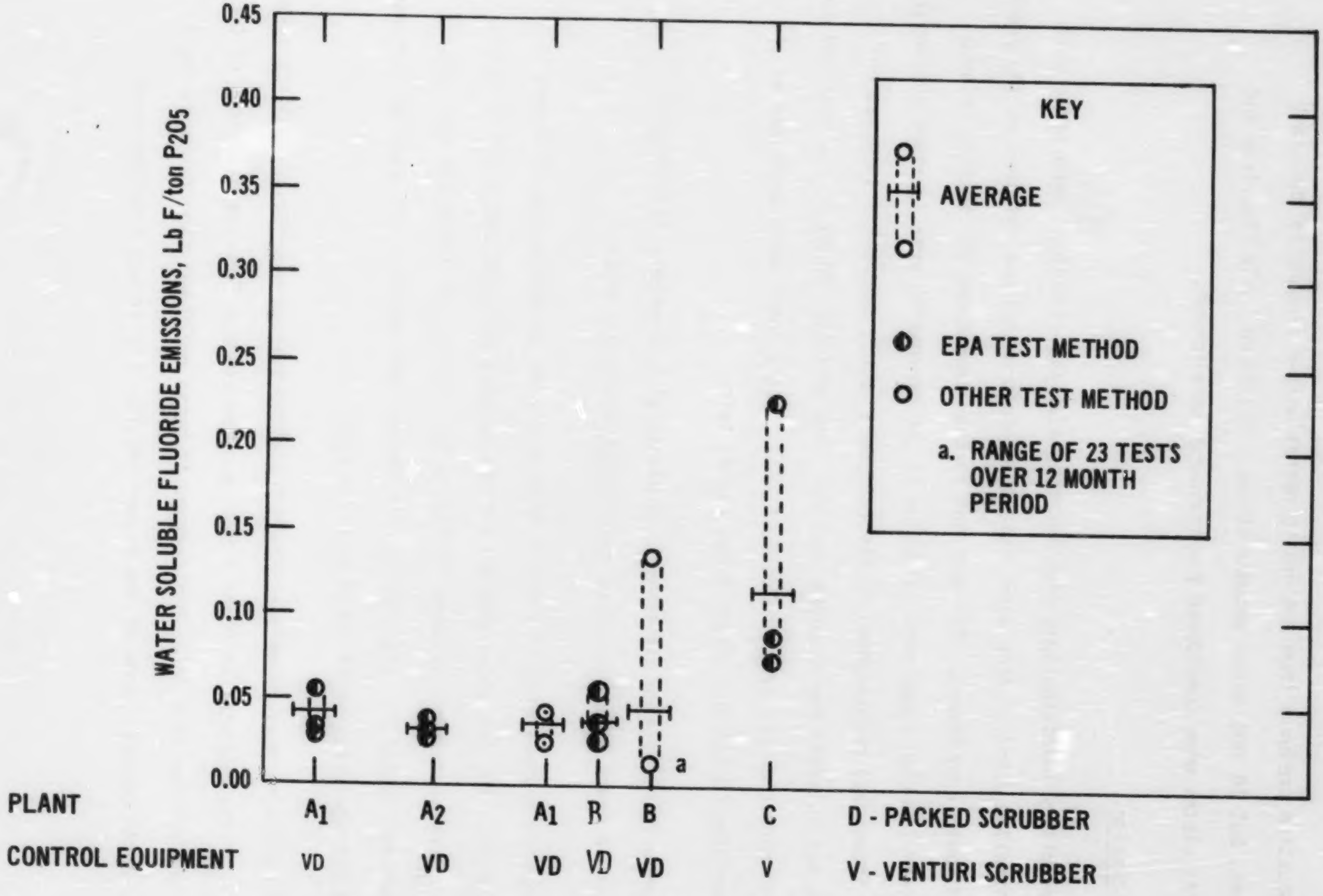
During the initial plant surveys, 9 plants with scrubbers exhibited no visible stack emissions other than uncombined water vapor.

Emission measurements at Plant A were conducted by EPA during different seasons. The two tests yielded average results of 0.040 and 0.028 lb F/ton P_2O_5, respectively, as shown in Figure 12. During the first EPA test the operator tested his plant using a different test method. His results indicated an average emission of 0.034 lb F/ton P_2O_5.

EPA emission measurements at Plant B yielded average results of 0.039 lb F/ton P_2O_5. The operator of Plant B has reported average fluoride emissions of 0.041 pound per ton of P_2O_5. This average is based on 23 emission tests during a 12-month period. Some of the higher results vary enough from the mean

FIGURE 12

FLUORIDE EMISSIONS FROM DIAMMONIUM PHOSPHATE PLANTS



to question their validity as part of the total sample population with 99-percent confidence. However, they have been included in Figure 12.

Plant C was tested by EPA to estimate an emission factor for DAP plants as part of an industrial study which preceded the program for developing standards. Plant C compromises fluoride control. Rather than install a separate water scrubber to control fluorides, they use a weak acid (22 percent P_2O_5) in an attempt to recover ammonia, particulates, and fluorides in a single scrubber. Data from Plant C were not considered in the development of a recommended new source performance standard for DAP plants.

All tests were conducted by EPA while the plants were operating at or near the design production rate. A complete summary of test data for Plants A and B can be found in Volume 2. Since Plant C was tested under another study, the test data from that plant are not presented in Volume 2 but may be obtained from the Emission Standards and Engineering Division.

The proposed standard of 30 grams of fluoride per metric ton of P_2O_5 input (0.06 pound per ton) is supported by emissions measured by EPA from Plant A and Plant B as presented in Figure 12. This standard will require installation and proper maintenance of equipment representative of the best technology which has been demonstrated for the industry. In the Administrator's judgment, the achievability of the proposed standards has been adequately demonstrated.

The proposed visible emission standard of 20 percent is based on data obtained in February 1974. Visible emissions were read simultaneously by two qualified observers during a valid one-hour test. Other data collected at the DAP plant were not considered representative due to problems with the control equipment during part of the test and because during another portion, the plant was forced to reduce its production below normal due to operational problems.

RUN-OF-PILE TRIPLE SUPERPHOSPHATE PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new run-of-pile triple superphosphate (ROP-TSP) production plants and ROP-TSP storage piles. The proposed standards would limit emissions of total fluorides from the run-of-pile triple superphosphate plant (including the storage building(s)), which is the affected facility. Major sources include but are not limited to the TVA cone mixer, curing belt (den), transfer conveyors, and storage piles. The standards apply at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized. The same standards are being proposed for granular triple superphosphate plants and will be discussed for such plants in a separate section.

Total Fluorides

No more than 100 grams of total fluoride per metric ton of P_2O_5 input (0.20 pound per ton).

Visible Emissions

Visible emissions shall be less than 20 percent opacity.

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DESCRIPTION OF PROCESS

Measured quantities of ground rock and 54-percent P_2O_5 phosphoric acid are combined in a mixer (Figure 13). The resultant viscous slurry drops onto a slowly moving belt (or den) where it solidifies. When the porous mass reaches the end of the belt, it is reduced to small chunks by a cutter. The ROP-TSP is then conveyed to a storage pile where the reaction continues. After approximately 30 days the reaction is complete, and the product is considered "cured" and ready for shipment.

EMISSIONS AND METHODS OF CONTROL

Emissions of fluorides and particulates occur during the production, conveying, and storage of ROP-TSP. Emissions from storage are greater during periods when the pile is being rearranged than when it has lain undisturbed for an extended period.

Uncontrolled ROP-TSP plants can release 1 pound of fluoride per ton of P_2O_5.[18] A typical uncontrolled 600-TPD installation would emit 600 pounds of fluoride each day of operation.

The best demonstrated control of fluoride consists of scrubbing emissions with water. No visible emissions were observed from storage facilities with this type of control. This verifies good control of particulate emissions.

Several State and local regulations limit fluoride emissions from ROP-TSP plants. Some restrict the mass of emissions per unit of production.

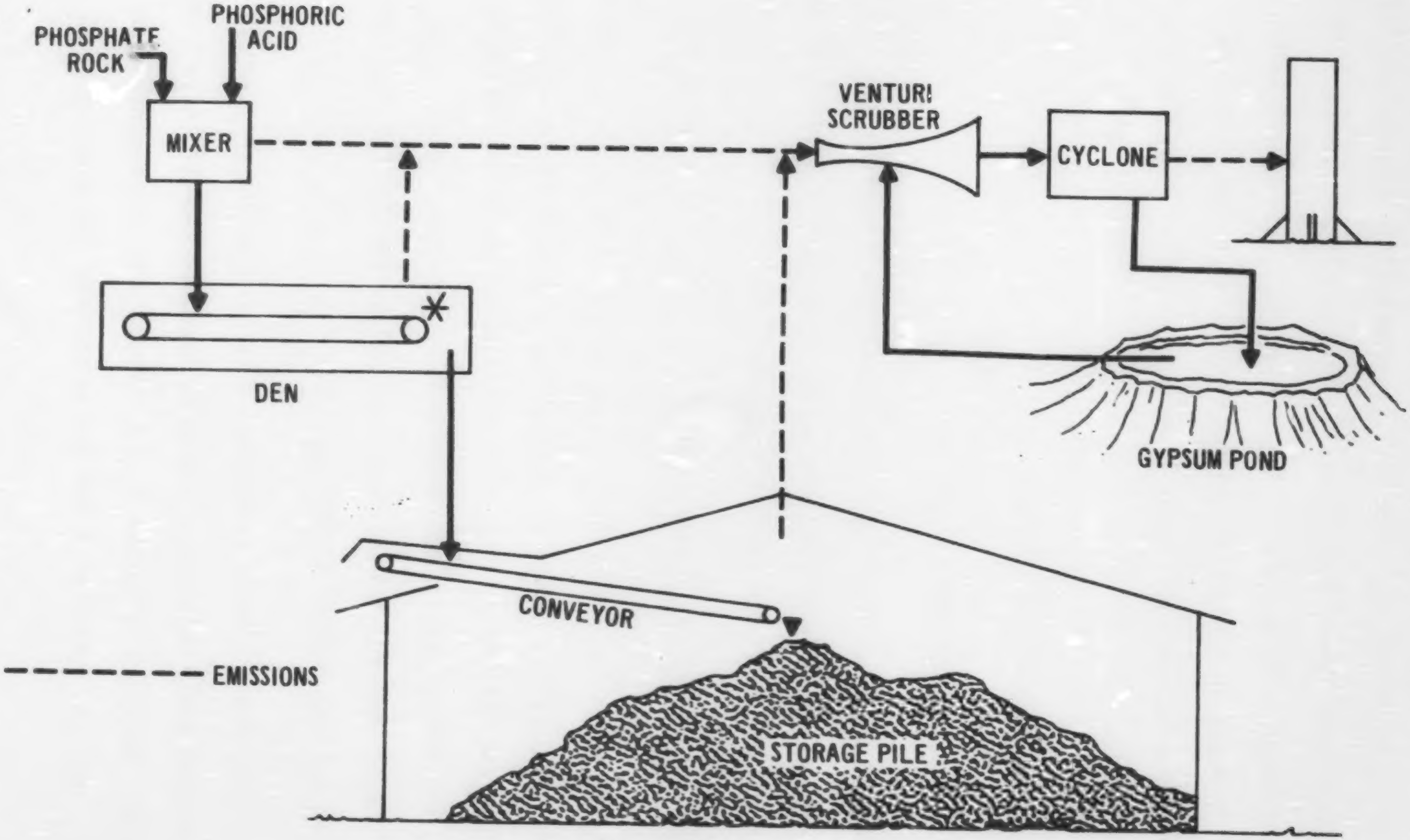

PHOSPHATE ROCK
PHOSPHORIC ACID
MIXER
DEN
VENTURI SCRUBBER
CYCLONE
GYPSUM POND
CONVEYOR
STORAGE PILE
EMISSIONS

Figure 13.
RUN-OF-PILE TRIPLE SUPERPHOSPHATE PRODUCTION AND STORAGE

Others are based on the fluoride content of surrounding vegetation or ambient air concentrations.[1] The most stringent State regulation, 0.17 pound fluoride per ton of P_2O_5 input,[17] would permit the typical 600-TPD P_2O_5 plant to emit 102 pounds of fluoride per day. (This limitation, however, is based on the analytical technique used by the State and cannot be directly compared to the proposed standards of performance.)

RATIONALE FOR PROPOSED STANDARDS

Selection of Pollutants for Control

The major pollutants emitted from this process are fluorides and particulate matter. Reasons for the decision to require control of only fluorides are presented in the Introduction.

Selection of Units for the Standard

Considerable attention was devoted to the selection of units for ROP-TSP standards. Initially, separate standards were considered for ROP-TSP manufacture and ROP-TSP storage since emissions from one of the major sources, the storage pile, are independent of production rate. Most manufacturers, however, have a single control system for the two sources. Therefore, this approach was not practical.

With a single control device, emissions from manufacture and storage cannot be separately measured. Standards based on storage factors were considered. However, emissions from a storage pile are dependent on turnover, age, and quantity of ROP-TSP in storage. Incorporation of a "turnover" factor in the units of the standards was not considered because of the extreme difficulty in quantifying and maintaining records of this activity. Standards based on age of the product were briefly considered because fresh ROP-TSP evolves more fluorides than cured ROP-TSP. The units of such standards, however, would be cumbersome, and enforcement would rely heavily on records kept by the manufacturer.

The final decision to propose units of pounds of fluoride per ton of P_2O_5 input to the process seemed most appropriate since 90 percent of the total fluorides released from ROP-TSP are evolved during the mixing, setting, and conveying steps[19] and because total P_2O_5 input to the process is routinely measured.

Discussion

Seven plants produce ROP-TSP in the United States.[22] One does not control fluorides from the storage pile. The remaining six were visited, visible emissions were evaluated, and information was obtained on the process and control equipment. Four were not further considered for testing because emissions were excessive (perhaps the result of inadequate maintenance), because the equipment (e.g., ductwork configuration) was not suitable for accurate testing, or because a test could not be scheduled (e.g., one plant only operated 3 to 6 weeks per year).

During the initial plant surveys, five plants with scrubbers exhibited no visible stack emissions other than uncombined water vapor. Three of these were not tested for reasons listed above.

Results of the three tests conducted by EPA at two plants (Figure 14) reveal average emissions of 0.19, 0.21, and 0.12 pound of fluoride per ton of P_2O_5 input. Individual samples ranged from 0.03 to 0.31 pound of fluoride per ton P_2O_5 input. Average results of similar tests by the operator of Plant A over the previous year tend to support the averages obtained by EPA. The average of 35 tests was 0.16 pound of fluoride per ton of P_2O_5 input. Figure 14 also presents emission measurement data submitted by the operator of a plant controlled by cyclonic scrubbers (Plant B). The measured emission rate from this installation was 0.08 pound of fluoride per ton of P_2O_5 input. These plant tests were not performed in accordance with EPA test procedures.

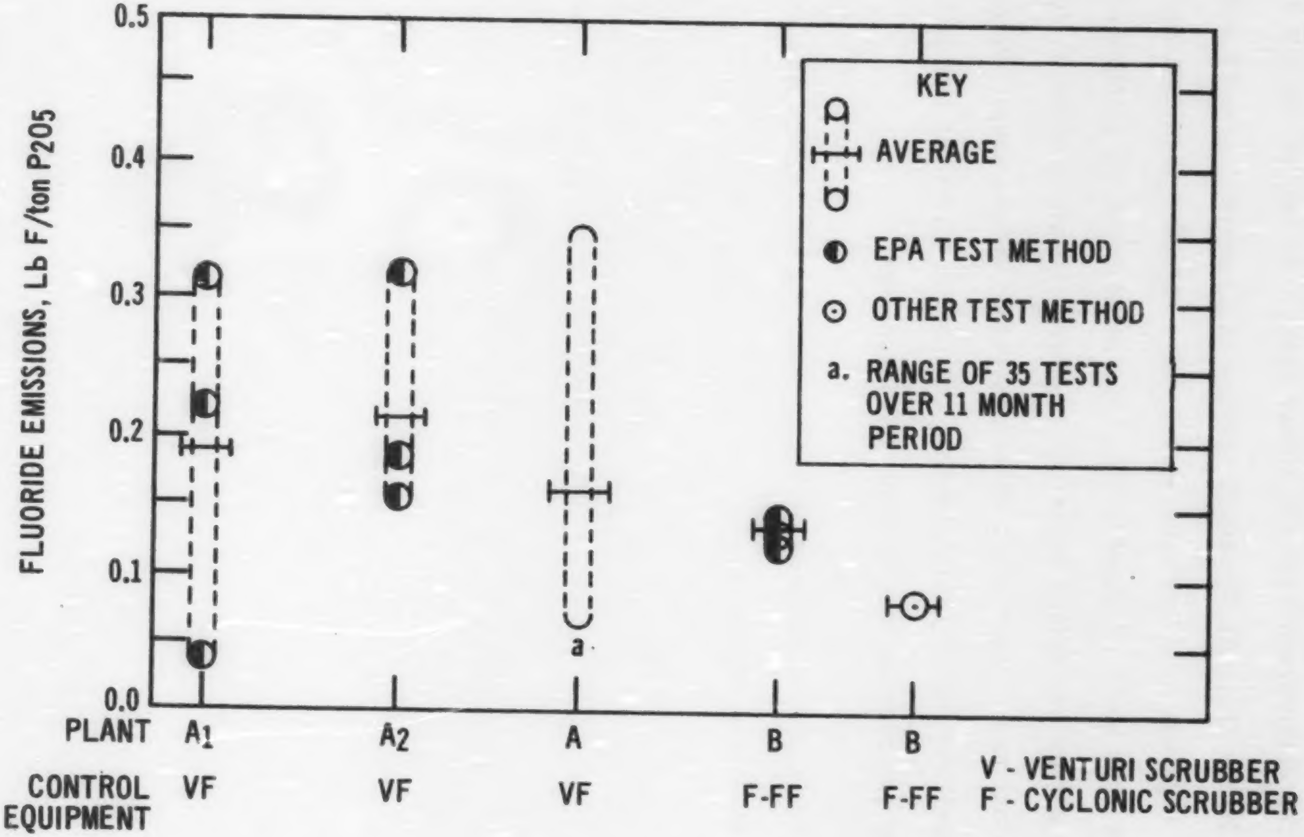
All tests were conducted by EPA while the plants were operating at or near their design production rates. A complete summary of test results can be found in Volume 2.

The proposed standard of 100 grams of fluoride per metric ton of P_2O_5 input (0.20 pound per ton) is supported by emissions measured from Plants A and B as presented in Figure 14. This standard will require installation and proper maintenance of equipment representative of the best technology which has been demonstrated for the industry.

The Agency originally considered proposing a standard of 150 g F/metric ton (0.3 lb F/ton P_2O_5) based on the actual emission tests of best-controlled plants. However, like SC-SPA plants, ROP-TSP plants have not been fitted with the more efficient control equipment typical of other phosphate fertilizer processes. It is estimated that a packed scrubber could possibly limit emissions to as low as 0.06 lb F/ton P_2O_5, based on a typical 400,000 scf/ton effluent at three ppm exit concentration.

FIGURE 14

FLUORIDE EMISSIONS FROM RUN-OF-PILE TRIPLE SUPERPHOSPHATE PLANTS



The proposed visible emission standard of 20 percent is based on data obtained in February 1974. Visible emissions were read simultaneously by two qualified observers during two 2-hour tests. At one of the ROP-TSP plants tested by EPA, one 15-second reading at 25 percent opacity and three minutes of readings at 20 percent opacity were recorded in a 5-minute time span during four hours of observation. No reason could be determined for this short period of visible emission; however, the plant operator indicated that the plant never has visible emissions except during upset conditions. These unusual and inexplicable readings were not included in the data for determining the opacity standard for ROP-TSP plants.

In the Administrator's judgment, the achievability of the proposed standard has been adequately demonstrated.

GRANULAR TRIPLE SUPERPHOSPHATE PLANTS

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new granular triple superphosphate (GTSP) production plants. The proposed standard would limit emissions of total fluorides from the granular triple superphosphate plant, which is the affected facility. Major sources include but are not limited to the reactor, granulator, dryer, cooler, screens, and mills. The standards apply at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized.

The proposed standards would limit emissions to the atmosphere as follows:

Total Fluorides

No more than 100 grams of total fluoride per metric ton of P_2O_5 input to the process (0.20 pound per ton).

Visible Emissions

Visible emissions shall be less than 20 percent opacity.

DESCRIPTION OF PROCESS

The direct-slurry process for production of granular triple superphosphate begins with the reaction of phosphate rock and phosphoric acid. The reaction proceeds as indicated:[19,20]

$$Ca_3(PO_4)_2 + 4\ H_3PO_4 + 3\ H_2O \rightarrow 3[CaH_4\ (PO_4)_2 \cdot H_2O]$$

A schematic diagram of the process is shown in Figure 15. The reactor slurry is pumped to the granulator where it is mixed with undersize material from the product screens. From the granulator, the granules flow to a rotary drier. After drying, the 46 percent P_2O_5 product is cooled and screened before being conveyed to the storage building.

In a somewhat similar process, granular triple superphosphate is also produced by granulating cured run-of-pile triple superphosphate (ROP-TSP). Such a plant does not require a prereactor, but all other facilities are the same as those described for the direct-slurry granulation process. As would be expected, emissions from plants processing cured ROP-TSP are much lower than from the direct-slurry process since a significant portion of the fluorides were evolved when the triple superphosphate was initially manufactured in the run-of-pile form. Consequently, emission levels from the GTSP plant using ROP-TSP as a raw material have not been investigated. Plants which manufacture GTSP from cured ROP-TSP will not be subject to the proposed standard.

EMISSIONS AND METHODS OF CONTROL

In addition to the gaseous forms, fluoride is emitted from granular triple superphosphate plants in mists entrained from the scrubbers or in solid particulates carried from both the granulator and dryer.

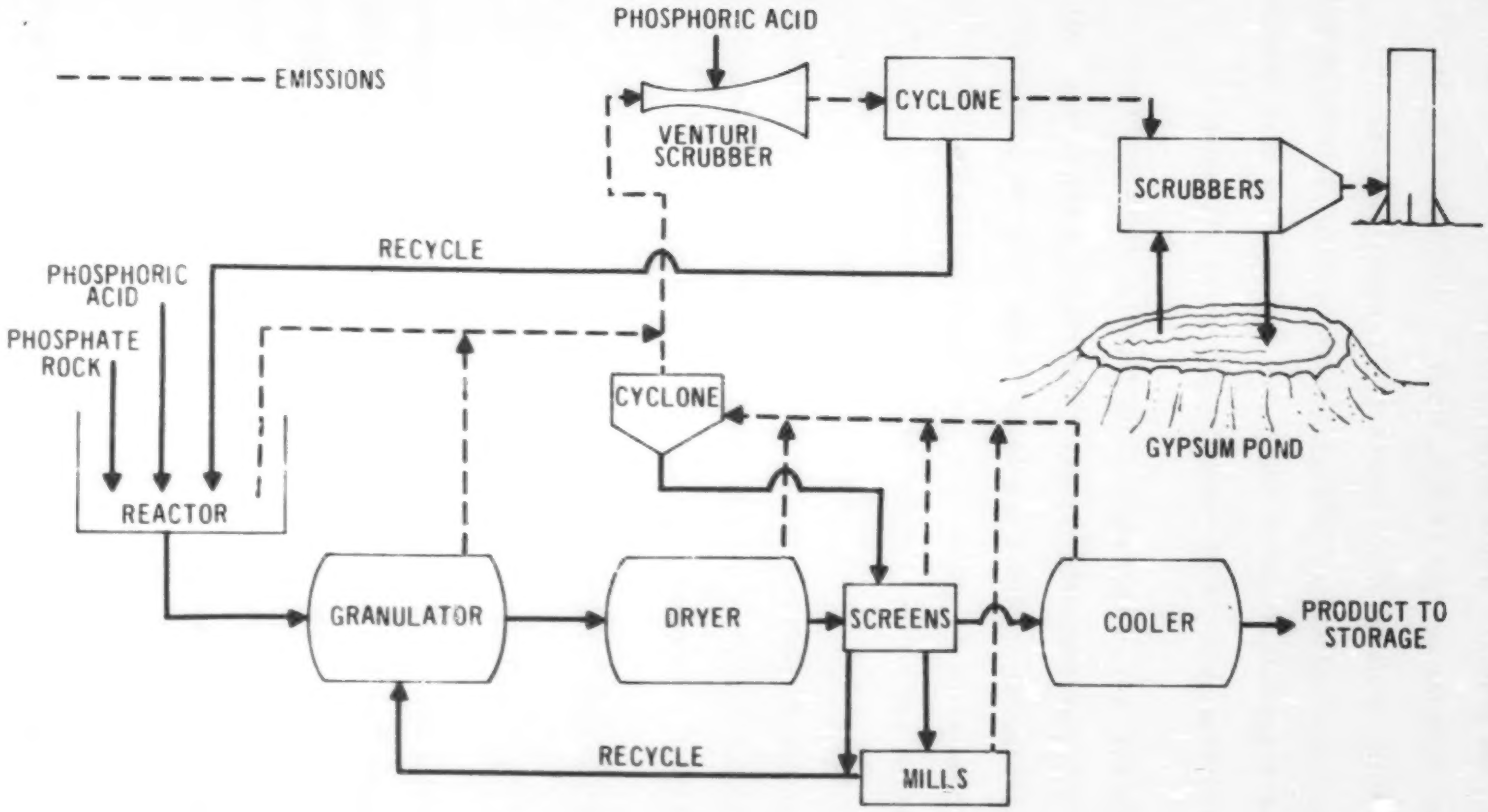

EMISSIONS
PHOSPHORIC ACID
VENTURI SCRUBBER
CYCLONE
SCRUBBERS
RECYCLE
PHOSPHORIC ACID
PHOSPHATE ROCK
REACTOR
CYCLONE
GYPSUM POND
GRANULATOR
DRYER
SCREENS
COOLER
PRODUCT TO STORAGE
RECYCLE
MILLS

Figure 15. GRANULAR TRIPLE SUPERPHOSPHATE PRODUCTION

Poorly controlled granular triple superphosphate plants can release up to 0.60 pound of fluoride per ton of P_2O_5 input.[1] A 500-TPD P_2O_5 installation with such control would emit 300 pounds of fluorides each day of operation. Well-controlled GTSP plants can achieve fluoride emission levels below 0.30 lb F/ton P_2O_5 input or 150 pounds per day. The best demonstrated control of fluoride consists of scrubbing off-gases with water.[11]

Several State and local regulations limit fluoride emissions from granular triple superphosphate plants. Some restrict the mass of emissions per unit of production. Others are based on the fluoride content of surrounding vegetation or ambient air concentrations.[1] The most stringent State regulation (as proposed in the State implementation plans), 0.15 pound fluoride per ton of P_2O_5 input, would permit the typical 500-TPD P_2O_5 plant to emit 75 pounds of fluoride per day.[17] (This limitation, however, is based on the analytical technique used by the State and cannot be directly compared to the proposed standards of performance.)

RATIONALE FOR PROPOSED STANDARDS

Selection of Pollutants for Control

The major pollutants emitted from this process are fluorides and particulate matter. Reasons for the decision to require control of only fluorides are presented in the Introduction. Since control of fluoride will inherently provide some control of particulate, only an opacity standard is recommended to assure particulate control.

Discussion

Preliminary investigations revealed the location of several reportedly well-controlled plants. Six were visited, visible emissions were evaluated, and information was obtained on the process and control equipment. Four were not further considered for testing because either fluoride fumes were excessive in the processing area (perhaps the result of inadequate maintenance) or the equipment (e.g., ductwork configuration) was not suitable for accurate testing. Three tests were conducted at the remaining two locations.

During the initial plant surveys, 6 plants with scrubbers exhibited no visible stack emissions other than uncombined water vapor.

Two tests were conducted at Plant A. The results yielded average emissions of 0.18 and 0.06 lb F/ton P_2O_5, respectively. Source tests by the operator on the same day as the first EPA test indicated average emissions of 0.12 lb F/ton P_2O_5.

The test at Plant B yielded average emissions of 0.21 lb F/ton P_2O_5.

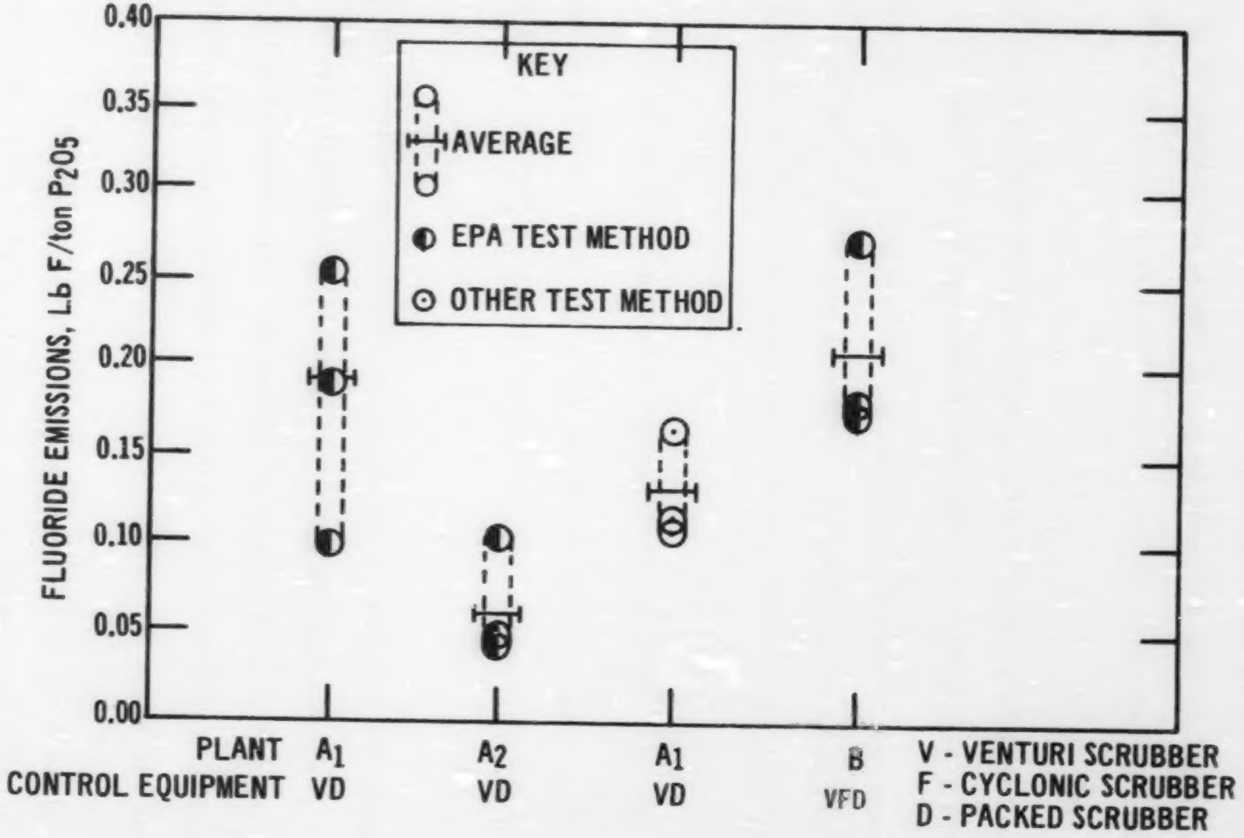
Tests were conducted by EPA while the plant was operating at nor near its design production rates. A complete summary of test data can be found in Volume 2.

The proposed standard of 100 grams of fluoride per metric ton of P_2O_5 input (0.20 pound per ton) is supported by emissions measured during two tests of Plants A and B as presented in Figure 16. This standard will require installation and proper maintenance of equipment representative of the best technology which has been demonstrated for the industry.

The Agency originally considered establishing a standard of 150 g F/metric ton (0.30 lb/ton) based on the measured emission data. However, upon presentation of this standard at the NAPCTAC meeting on February 21, 1973, the committee recommended the data be reviewed to see if a more stringent

FIGURE 16

FLUORIDE EMISSIONS FROM GRANULAR TRIPLE SUPERPHOSPHATE PRODUCTION PLANTS



standard could be justified. Based on a reevaluation, the following conclusions were reached.

a. TSP plants are among the highest fluoride emitters in a phosphate fertilizer complex. A reduction in fluoride emissions from 0.30 to 0.20 lb/ton P_2O_5 is equivalent to a reduction of about 30 pounds of fluoride per day for a typical plant producing 300-350 tons of P_2O_5 per day.

b. Tests by EPA showed that fluoride emissions of less than 0.2 lb/ton P_2O_5 can be achieved. EPA performed two tests (3 runs each) on a GTSP plant. Fluoride emissions for all but one of the six runs were less than 0.2 lb/ton P_2O_5.

c. Fluoride concentrations of three ppm, equivalent to 0.1 lb/ton of P_2O_5 for GTSP plants can be achieved using packed scrubbers. (Based on 600,000 scf of exhaust gases per ton P_2O_5, typical of this process).

The proposed visible emission standard of 20 percent is based on data obtained in February 1974. Visible emissions were read simultaneously by two qualified observers during two 2-hour tests. Some data collected were not representative of normal operation and were not considered in developing the standard. At one GTSP plant visible emissions up to 25 percent opacity occurred while burning No. 5 fuel oil in the dryer. A check by plant personnel revealed an abnormally large quantity of sediment in the fuel oil tank. Emissions from identical dryers at other GTSP plants burning fuel oil have been observed at less than 10 percent opacity.

On the basis of this information, in the Administrator's judgment, achievability of the proposed standards has been adequately demonstrated.

GRANULAR TRIPLE SUPERPHOSPHATE STORAGE

SUMMARY OF PROPOSED STANDARDS

Standards of performance are being proposed for new granular triple superphosphate (GTSP) storage facilities. The proposed standard would limit emissions of fluorides from the storage building, which is the affected facility. Major sources include but are not limited to the product pile, transfer conveyors and elevators, screens, and mills. The standards apply at the point(s) where emissions are discharged from the air pollution control system or from the affected facility if no air pollution control system is utilized.

The proposed standards would limit emissions to the atmosphere as follows:

Total Fluorides

No more than 0.25 gram total fluoride per hour per metric ton of P_2O_5 in storage (5×10^{-4} pound per hour per ton).

Visible Emissions

Visible emissions shall be less than 20 percent opacity.

DESCRIPTION OF PROCESS

After manufacture, GTSP is moved to a storage building where it remains until the reaction is completed or the product is "cured." Figure 17 illustrates the activities in the storage building. The GTSP is distributed

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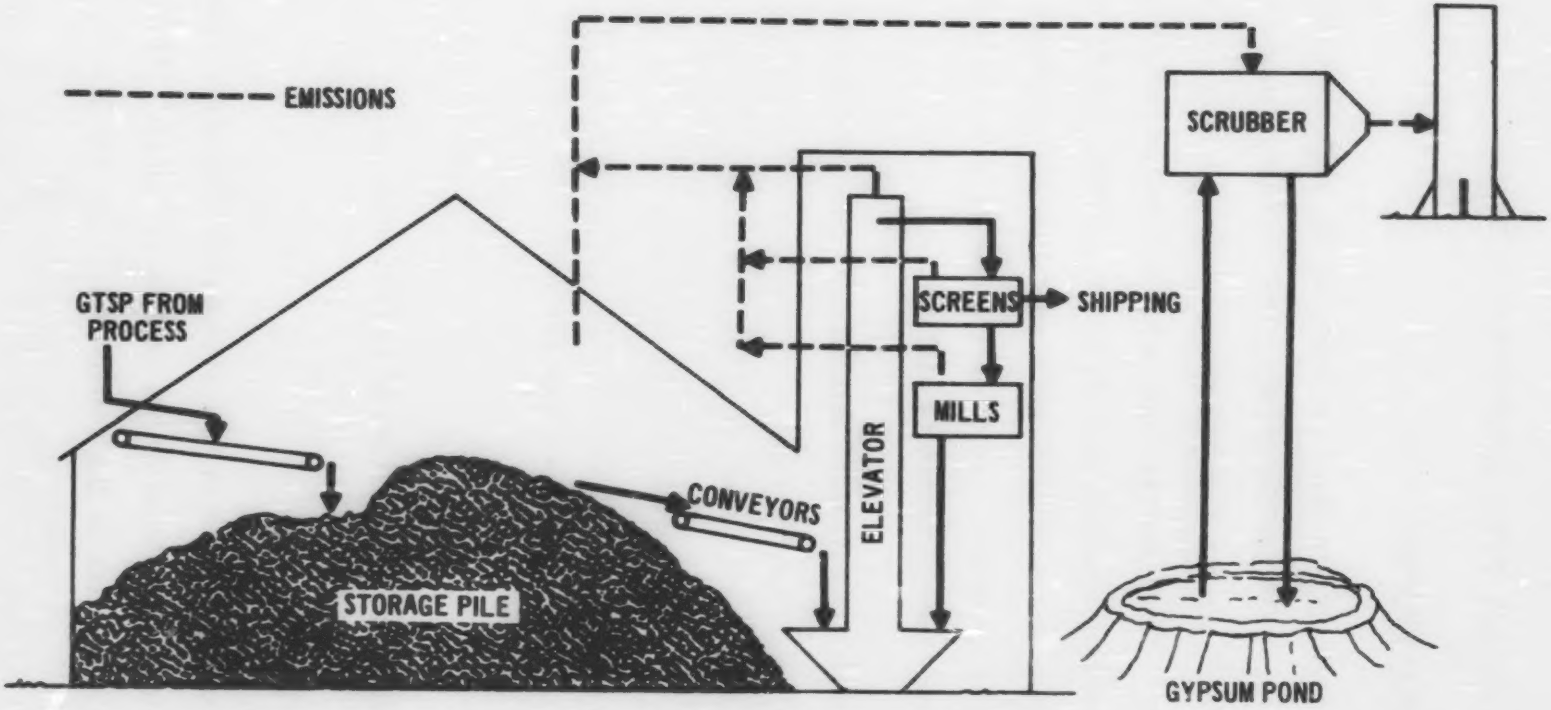

EMISSIONS
GTSP FROM PROCESS
SCRUBBER
SCREENS
SHIPPING
MILLS
ELEVATOR
CONVEYORS
STORAGE PILE
GYPSUM POND

Figure 17. GRANULAR TRIPLE SUPERPHOSPHATE STORAGE

to a predetermined area in the building by conveyors. After 3 to 5 days, during which fluorides evolve from the storage pile, the product is considered cured and ready for shipping. Front-end loaders move the GTSP to elevators or hoppers where it is conveyed to screens for size separation. Oversize material is rejected, pulverized, and returned to the screen. Undersize material is returned to the GTSP production plant. Material within specification is shipped as product.

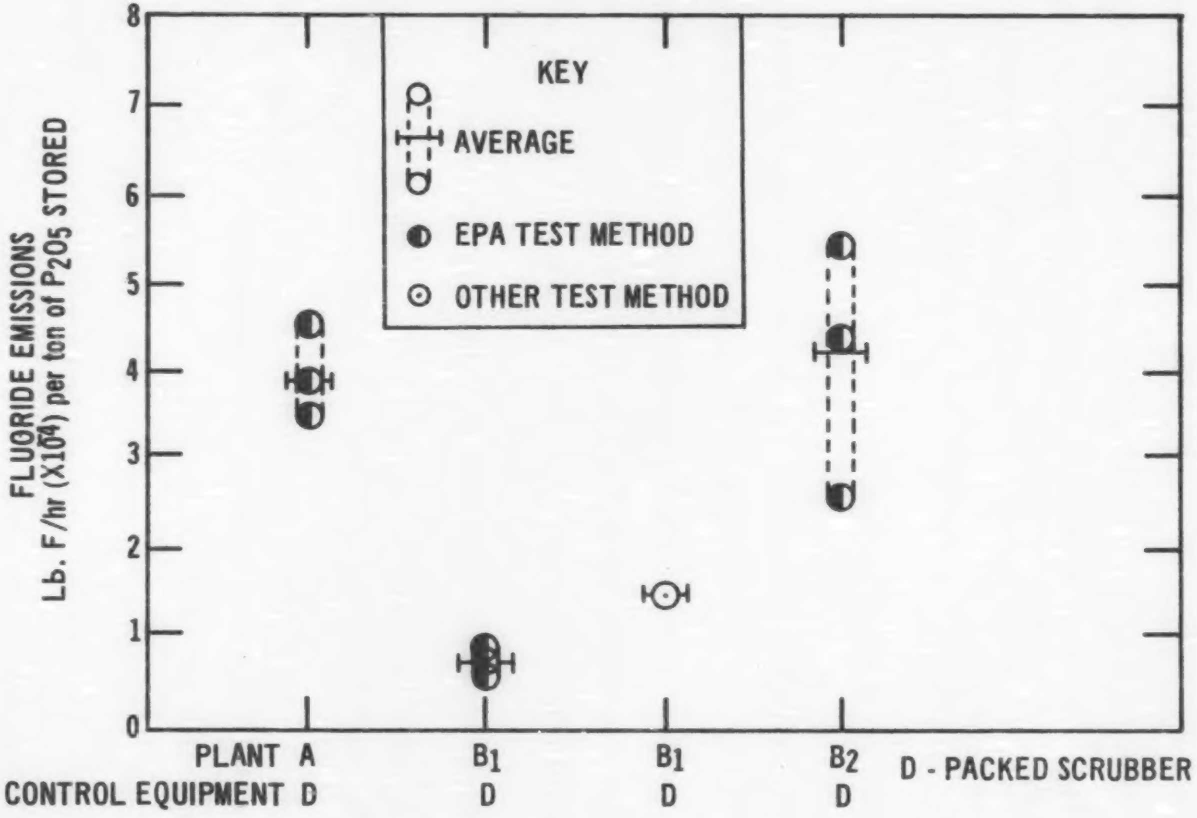
EMISSIONS AND METHODS OF CONTROL

Emissions from GTSP storage are limited to fluorides and particulates. The fluorides are emitted both in the gaseous form and as a constituent of the particulate emissions. Emissions of gaseous and solid particulate fluorides are greater during periods when the GTSP product is being rearranged rather than when it is in piles where it has lain undisturbed.

Some poorly controlled GTSP storage facilities can release as much as 15×10^{-4} pound of fluoride per hour per ton of P_2O_5 in storage. Such a storage facility with 1,500 tons of P_2O_5 could emit 55 pounds of fluoride each day of storage. Well-controlled GTSP storage facilities can restrict fluoride emissions to less than 5×10^{-4} pound fluoride per hour per ton of P_2O_5 stored (see Figure 18). A well-controlled 1,500-ton P_2O_5 storage facility achieving 5×10^{-4} pound of fluoride per hour per ton of P_2O_5 stored would emit about 18 pounds of fluoride each day of storage.

FIGURE 18

FLUORIDE EMISSIONS FROM GRANULAR TRIPLE SUPERPHOSPHATE
STORAGE FACILITIES



The best-demonstrated control of fluoride consists of scrubbing emissions with water.[11] No visible emissions were observed from storage facilities with this type of control. This verifies good control of fluoride and also provides incidental control of particulate emissions.

Several State and local regulations limit fluoride emissions from granular triple superphosphate storage facilities. Some restrict the mass of emissions per unit of production. Others are based on the fluoride content of surrounding vegetation or ambient air concentrations.[1] The most stringent State regulation, 0.05 lb F/ton P_2O_5 stored per day, would permit a 1,500-ton P_2O_5 storage facility to emit 75 pounds of fluoride per day.[17]

RATIONALE FOR PROPOSED STANDARDS

Selection of Pollutants for Control

Only fluorides and particulates are potential pollutants from this process. Reasons for the decision to require control of only fluorides are presented in the Introduction. Since control of fluoride will inherently provide some control of particulate, only an opacity standard is recommended to assure particulate control

Selection of Units for the Standard

This is the only one of the affected facilities in the phosphate fertilizer industry for which a standard of "pounds of fluoride per ton of P_2O_5 input" was not considered to be applicable. The amount of fluorides evolved from a storage pile is dependent on turnover, age, and quantity of the GTSP in storage. The proposed units are based on the quantity and age of the GTSP in the storage building.

Discussion

Preliminary investigations revealed the location of several reportedly well-controlled facilities. Six were visited, visible emissions were evaluated, and information was obtained on the process and control equipment. Four were not further considered for testing because the maintenance was inadequate or the equipment (e.g., ductwork configuration) was not suitable for testing. Three stack tests were conducted by EPA at the remaining two locations. Both plants utilized packed scrubbers with gypsum pond water as the scrubbing medium.

During the initial plant surveys, 6 plants with scrubbers exhibited no visible emissions other than uncombined water vapor.

The tests conducted by EPA indicate average emissions from Plant A are 4×10^{-4} pound fluoride per hour per ton of P_2O_5 stored (see Figure 18). The GTSP storage building was about 21 percent full during these source tests.

EPA's first test of Plant B indicated emissions averaged 1×10^{-4} pound fluoride per hour per ton P_2O_5 stored. Concurrent testing by the operator indicated 2×10^{-4} pound fluoride per hour per ton P_2O_5. The GTSP storage building was approximately 30 percent full during this period.

A second test of Plant B by EPA at a later date indicated 4 x 10^{-4} pound fluoride per hour per ton of P_2O_5. During this second test the storage building was about 15 percent full.

Tests were conducted by EPA while GTSP production was at or near design production rates and more than 20 percent of the GTSP in the building was manufactured within the 10 days prior to testing.

Also, as noted above for each test, the storage buildings ranged from 15-30 percent full. A complete summary of test data can be found in Volume 2.

The proposed standard will require that a storage building be filled to at least 10 percent capacity and that at least 20 percent of the GTSP stored be fresh (produced no longer than 10 days prior to testing) during a compliance test. If the provision requiring 20 percent of the material to be fresh exceeds production capabilities, the plant operator will be required to have greater than five days maximum production in the building during testing.

The minimum amount of product stored (10 percent of the building's capacity) is required because the standard becomes unduly restrictive when very small inventories are present in the building. The denominator in the units of the proposed standard is the amount of material stored. If this quantity is small the allowable pounds per hour of emissions is correspondingly small. With low inlet concentrations to the scrubber (because of the small amount of material stored), some fluorides may be stripped from the contaminated scrubbing medium. Emissions in terms of "pounds per hour per ton P_2O_5 stored" may then exceed the standard even though they are small in terms of pounds per hour.

A minimum amount of fresh material is required to be stored during testing since, as mentioned earlier, fresh GTSP evolves more fluoride than cured GTSP.

The proposed standard of 0.25 gram of fluoride per hour per metric ton of P_2O_5 in storage (5 x 10^{-4} pound per hour per ton) is supported by emissions measured from the plants as presented in Figure 18. This standard will require installation and proper maintenance of equipment representative of the best technology which has been demonstrated for the industry.

The proposed visible emissions standard of 20 percent is based on data obtained in February 1974. Visible emissions were read simultaneously by two qualified observers during two 2-hour tests.

In the Administrator's judgment, the achievability of the proposed standards has been adequately demonstrated.

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APPENDIX A

THE ECONOMIC IMPACT OF STANDARDS OF PERFORMANCE ON THE PHOSPHATE FERTILIZER INDUSTRY

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I. Overview

A. Scope

The purpose of this paper is to examine the background of the phosphate industry and to analyze the economic impact of proposed standards of performance upon the industry. The scope of this study is limited to new sources only, that will fall under jurisdication of section 111(b).

After promulgation of standards of performance for a designated pollutant, such as fluorides, existing manufacturing facilities become subject to emission regulations under State implementation plans, similar to those designed for achievement of national ambient air quality standards. This requirement is under section 111(d) of the Clean Air Act. This appendix does not discuss sources subject to section 111(d).

B. Summary

Costs for control of fluoride emissions under the standards of performance for wet-process phosphoric acid (WPPA), superphosphoric acid (SPA), and diammonium phosphate (DAP) manufacturing are minor, amounting to less than 1 percent in sales price at the wholesale level (phosphate producer). Costs for emissions control for run-of-pile triple superphosphate is about 2 percent of wholesale price and for granular triple superphosphate, 4 percent.

The growth for new facilities in the phosphate industry will be fairly substantial during the 1970's. A growth rate of an approximate 6 percent is expected for new facilities in WPPA and DAP. Calculations yield 2 WPPA units per year of the 900-TPD (P_2O_5 basis) size and approximately 3 DAP plants (500-TPD P_2O_5) per year. No estimates have been made for replacement of existing facilities; most facilities in the industry today are less than ten years old. Some 3 SPA units of the 300-TPD (P_2O_5) size will be built.

Little growth is expected for run-of-pile triple superphosphate production; only slight growth is expected for granular triple superphosphate because of increasing competition from diammonium phosphate and concentrated liquids production (SPA), particularly in the area of manufacture of mixtures. Projected granular triple superphosphate production is expected to be conducted by complexes designed for multi-product operations. Therefore, facilities equipped for DAP manufacture will also produce GTSP to satisfy demand for direct application materials and overseas exports. Three new storage units are expected to be built during the 1970's, each unit to accommodate 250-TPD (P_2O_5) GTSP production.

The impact of standards of performance upon the fertilizer industry will be minimal, both for domestic consumers and the balance of trade. While demand for phosphate products are relatively inelastic, cross elasticities of demand do exist among competitive phosphate products (i.e., high analysis products vs. low analysis products, bulk goods vs. bagged goods, solid fertilizers vs. liquid, for some samples of competition). The standards of performance will not be a deterrent to those products that are gaining acceptance with farmers. They will only accelerate this trend as control costs will further prohibit manufacture of run-of-pile triple superphosphate and GTSP for the mixed fertilizers markets.

Lastly, a standard has been proposed for SPA to allow two competitive manufacturing processes to remain as viable alternatives to producers; namely, the submerged combustion and the vacuum evaporation processes. A control cost of \$0.28 per ton P_2O_5 for the submerged process has been calculated for a system that represents a technology transfer from DAP manufacturing. It is estimated that the vacuum evaporation process can attain 0.01 lb F/ton P_2O_5 without control. This would appear to be a cost disadvantage for the submerged process; however, the impact of the standard upon the industry is expected to be negligible.

II. Economic Profile

A. Industry Structure

The phosphate fertilizer industry is only a segment of the agricultural chemical industry that is devoted to the production and marketing of commodities bearing the basic nutrients--nitrogen, phosphorous, and potash--for crop production. From the perspective of end-use products, the scope of the agricultural chemical industry includes ammonia, ammonium nitrate, urea, ammonium phosphates, nitrophosphates, mixed plant foods (in varying N-P-K combinations), superphosphates, phosphoric acid, and potash. The phosphate production sector of the agricultural chemical industry begins with the mining of phosphate rock, proceeds with the basic chemical production of phosphoric acid and its subsequent processing to diammonium phosphate (DAP), superphosphoric acid (SPA), and triple superphosphate (TSP), and culminates at the retailer level where many thousands of blends of fertilizers are formulated to satisfy the diverse interests of consumers. There are three basic types of retailers--granular NPK producers (manufacturers of chemical formulations), liquid fertilizer manufacturers, and mechanical (dry bulk) blenders. These three groups of retailers compete with each other in some markets (mixed fertilizers).

The basic chemical producers in the industry will sell merchant phosphoric acid and products derived from phosphoric acid, such as DAP or SPA. NPK producers can buy from a choice of raw materials then to produce a specific product. For example, the typical NPK plant operator can buy DAP or produce his own from wet-process phosphoric acid to satisfy a product demand. Therefore, some competition can be expected among the various phosphate concentrates.

The basic chemical producers, which are the focus of this analysis, are generally not identifiable as single product firms. Very few firms are totally dependent on fertilizer production for their business. Most fertilizer production is conducted as a subsidiary activity in well diversified, oftentimes large, corporations. These firms are chemical manufacturers or petrochemical companies. Some companies are farm cooperatives, vertically integrated from production to the marketing in geographic areas in which they are economically based. These latter firms are primarily engaged in serving farm customers in ways such as retailing fertilizers, purchasing and shipping grains and other agricultural products to regional centers, and providing necessary supplies and services for conduct of an agricultural economy. Thirdly, there are firms engaged in fertilizer production that derive the main portion of their revenues from totally unrelated activities, such as steel manufacture, pipeline construction, etc.

Generally, the basic chemical producers will own the sources of their raw materials (e.g., phosphate rock mines). According to 1970 production statistics(1), the ten largest firms in rock mining are ranked as follows:

TEN LARGEST PHOSPHATE ROCK PRODUCERS

Firm	Production (1000 Short Tons)
International Minerals & Chemicals	8,000
Continental Oil Company (now Williams Co.)	6,500
Mobile Chemical	5,900
Occidental Chemical Company	3,750
American Cyanamid	3,650
U.S.S. Agrichemicals	3,640
Swift & Company	3,000
Texas Gulf, Inc.	3,000
Stauffer Chemical Company	2,500
Cities Service, U.S. Phosphoric	2,000
Total U.S. Production	50,640
Percent of total production of ten largest firms	83%

Based on the production of wet process phosphoric acid, which is the cornerstone of the basic chemical production in this industry, the ten largest firms in terms of 1972 production are as follows:

TEN LARGEST PHOSPHORIC ACID PRODUCERS

Firm	Production (1000 Short Tons, P_2O_5)
CF Industries	838
Freeport Minerals	600
Cities Service, U.S. Phosphoric	544
Farmland Industries	455
Beker Agricultural Products	411
Texas Gulf, Inc.	346
Olin Corporation	337
W. R. Grace	300
U.S.S. Agri-Chemicals	266
J.R. Simplot	265
Total U.S. Production	6,114
Percent of total production of ten largest firms	71%

A review of the two above tabulations finds some vertical integration from the mine through the chemical production. Each of the phosphate rock producers named above owns basic chemical production facilities directly or through equity interest in chemical producing companies. CF Industries and Farmland Industries are integrated from the chemical production stage forward to the ultimate retailing of fertilizers. Freeport Minerals is strong in ownership of sulfur reserves, an important raw material for production of phosphoric acid. Beker Industries is a newcomer into the fertilizer industry as they purchased the fertilizer assets of Hooker Chemical (Occidental Petroleum) and El Paso Products Company.

B. Production

The scope of this study limits discussion to four basic commodities that are produced and traded. These are wet-process phosphoric acid, superphosphoric acid, triple superphosphate, and ammonium phosphates. Production data for 1960 through 1971 are presented in Table 1 for these commodities. A discussion of the features of these commodities follows.

1. Wet-Process Phosphoric Acid

The production of this chemical intermediate, which is the cornerstone of the industry, has grown at a phenomenal rate of 14 percent compounded annually for the period shown in Table 1. The growth has been due to the increased demand for phosphate nutrients over the years and due to the substitution from low analysis to high analysis products (triple superphosphate and diammonium phosphate) that require phosphoric acid for their production. High analysis products contain some 45 to 50 percent P_2O_5 as opposed to 18 to 24 percent P_2O_5 in low analysis products, such as normal superphosphate.

Wet-process phosphoric acid is used to produce triple superphosphate, diammonium (or monoammonium) phosphate, superphosphoric acid and complete NPK foods (those containing some formula of nitrogen, potash, and P_2O_5). Normally phosphoric acid is produced very near the rock mines to minimize the shipping charges as phosphoric acid is a more concentrated product than phosphate rock.

2. Triple Superphosphate

The production of triple superphosphate has been in a downtrend since 1966, which may indicate a likely course for future trends in production of run-of-pile triple superphosphate and a close substitute, monoammonium phosphate. Since 1960, triple superphosphate has grown at a compounded rate of 4 percent.

Triple superphosphate is produced by two methods; the den method and the granulator method. The den method produces a material (run-of-pile) that is non-uniform in particle size. This material is stored, pulverized, and shipped to NPK plants for ammoniation. The granulator method produces a granular product that is sold to bulk blender retailers for mixing or for direct application (as a 0-46-0 fertilizer) to the soil.

No statistics are available as to the breakdown of run-of-pile versus direct granulator production. In the industry, run-of-pile production by the primary producer may be granulated and sold as GTSP to bulk blender

TABLE 1. U.S. PRODUCTION OF THREE COMMODITIES IN THE PHOSPHATE INDUSTRY, 1960-1971 (1000 Tons of P_2O_5)

Year	Wet-Process Phosphoric Acid	Triple Super-phosphate[a]	Ammonium Phosphates[b]	Superphosphoric Acid[c]
1960	1325	986	269	35
1961	1409	1024	370	55
1962	1577	960	536	55
1963	1957	1113	786	75
1964	2275	1225	1016	120
1965	2897	1466	1081	188
1966	3566	1696	1376	260
1967	3752	1481	1747	418
1968	3861	1389	1633	NA
1969	3867	1354	1844	NA
1970	4642	1395	2070	NA
1971	5286	1381	2359	NA

[a] All grades containing 40 percent or more available P_2O_5 which have been made by acidulating rock with phosphoric acid.

[b] Mono- and diammonium phosphates and their processed combinations with ammonium sulfates. Excludes ammonium phosphates produced in combination with potash salts.

[c] Production derived from thermal acid and wet-process phosphoric acid, based on a marketing study of the industry conducted by Chemical Construction Company.

NA - Not available.

SOURCE: U.S. Department of Commerce, Current Industrial Reports.

retailers as a direct application fertilizer. Ultimately, essentially all run-of-pile production becomes granulated, either by the primary producer or by the NPK plant.

Triple superphosphate affords a way of shipping P_2O_5 values in a concentrated form, whether for distribution into domestic markets or for exports. Some 80 percent of triple superphosphate plant capacity is located in Florida near the rock mines.

3. Ammonium Phosphate

By definition, these are products manufactured directly from ammonia, phosphoric acid, and optionally other acids in contrast with those ammoniated phosphates produced in NPK granulation plants from ammonia and run-of-pile triple superphosphate. "Diammonium" phosphates include 16-48-0 and 18-46-0 grades. Monoammonium phosphates are 11-48-0. These two generic products are produced strictly from ammonia and phosphoric acid; other ammonium phosphates are produced from a mixture of ammonia, phosphoric acid, nitric acid, and possibly sulfuric acid.

Production of ammonium phosphate has grown at a rate of 20 percent compounded annually since 1960. The rapid growth has been at the expense of other competitive phosphate fertilizers. The following statistics will support this. In 1960, ammonium phosphates absorbed 20 percent of wet-process phosphoric acid production; in 1971, 45 percent. In contrast, triple superphosphate absorbed 52 percent of wet-process phosphoric acid production in 1960 and only 18 percent in 1971. (One ton of P_2O_5 in triple superphosphate requires 0.7 ton of P_2O_5 from phosphoric acid.)

NPK and superphosphoric acid production consume the remainder of wet-process phosphoric acid that is not used in ammonium phosphate and triple superphosphate processing.

4. Superphosphoric Acid

Superphosphoric acid is a concentrated form (70-75 percent P_2O_5) of thermal or wet-process phosphoric acid. Phosphoric acid is concentrated by two methods--(a) vacuum evaporation technique, and (b) submerged combustion process.

Documentation of superphosphoric acid production is very limited. The usual reporting groups, such as Department of Commerce and TVA, do not report production figures. The Fertilizer Institute reports production in its Fertilizer Index but privately concedes that its published figures for the years of 1969-1971 are far below estimates of actual production. Dr. William White(2) of the Fertilizer Institute estimates that 1972 production approaches 600,000 tons (P_2O_5 basis). This is significantly different than the 258,000 ton figure published in the Fertilizer Index for the 12-month period ending in June 1972.

Superimposing the 600,000 estimate on an imaginary trend line with data developed by Chemical Construction Company(3) would reinforce the latter's data trend. Linear regression analysis of the Chemical Construction Company data yields an historic growth rate of 35 percent from 1960 through 1968.

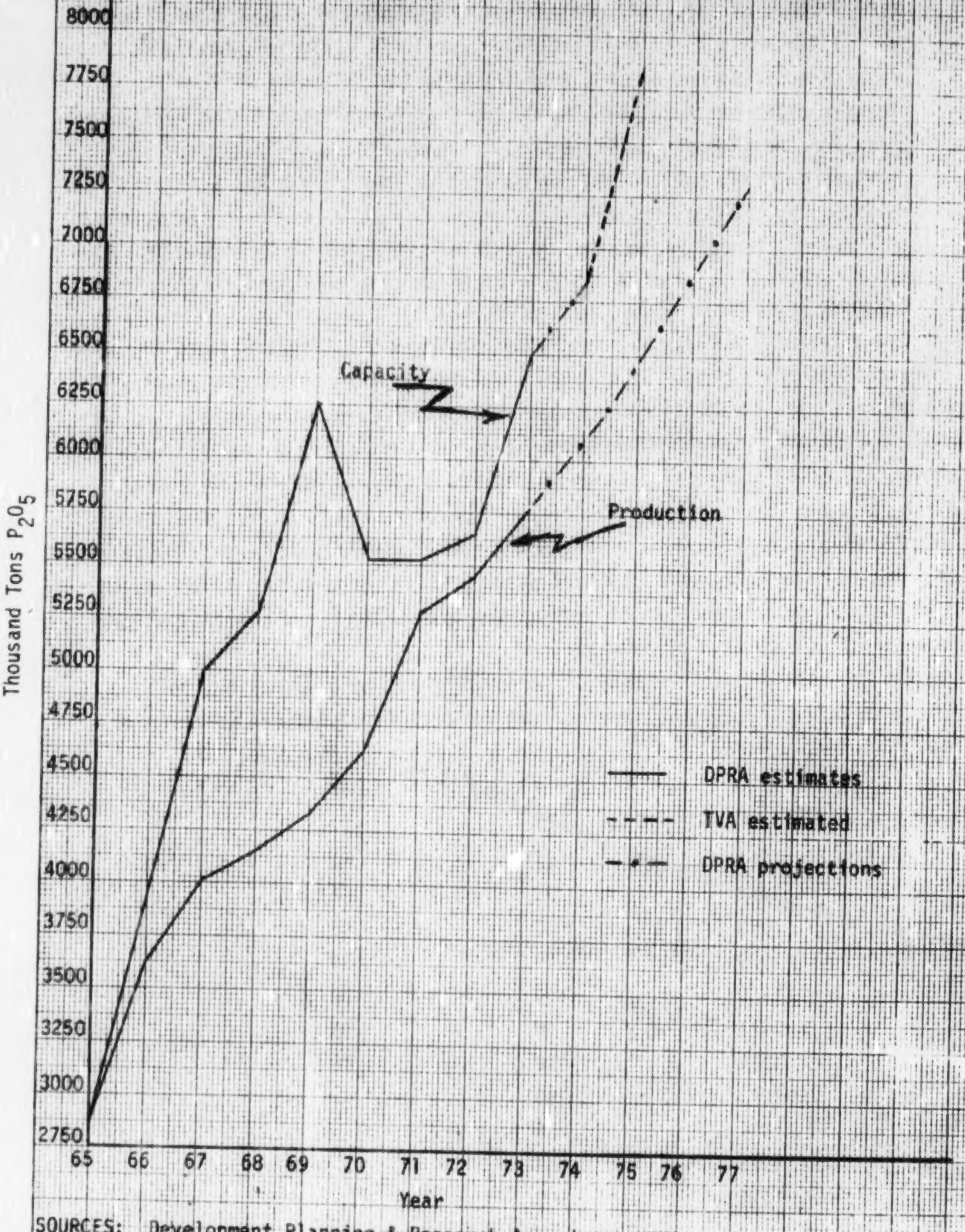
C. Capacity

The phosphate fertilizer industry has followed a cyclical pattern of capital investment in new plants. This pattern is demonstrated by the two graphs for phosphoric acid and ammonium phosphate (mostly diammonium phosphate; this term will be applied to ammonium phosphates produced directly from wet-process phosphoric acid) production, shown in Figures 1 and 2. As shown in the graphs by the duration between peak utilization (operating near 100 percent), the cycle length is about 6 to 7 years. During the 1965 to 1972 cycle, expansion peaked in 1969. Slackened demands prompted price cutting and eventual temporary shutdown of some facilities. At the end of the cycle, supply of plant capacity becomes in balance with production.

For an insight into the cyclical trend of capacity utilization, the following operating ratios are presented for phosphoric acid and diammonium phosphate production.(4)

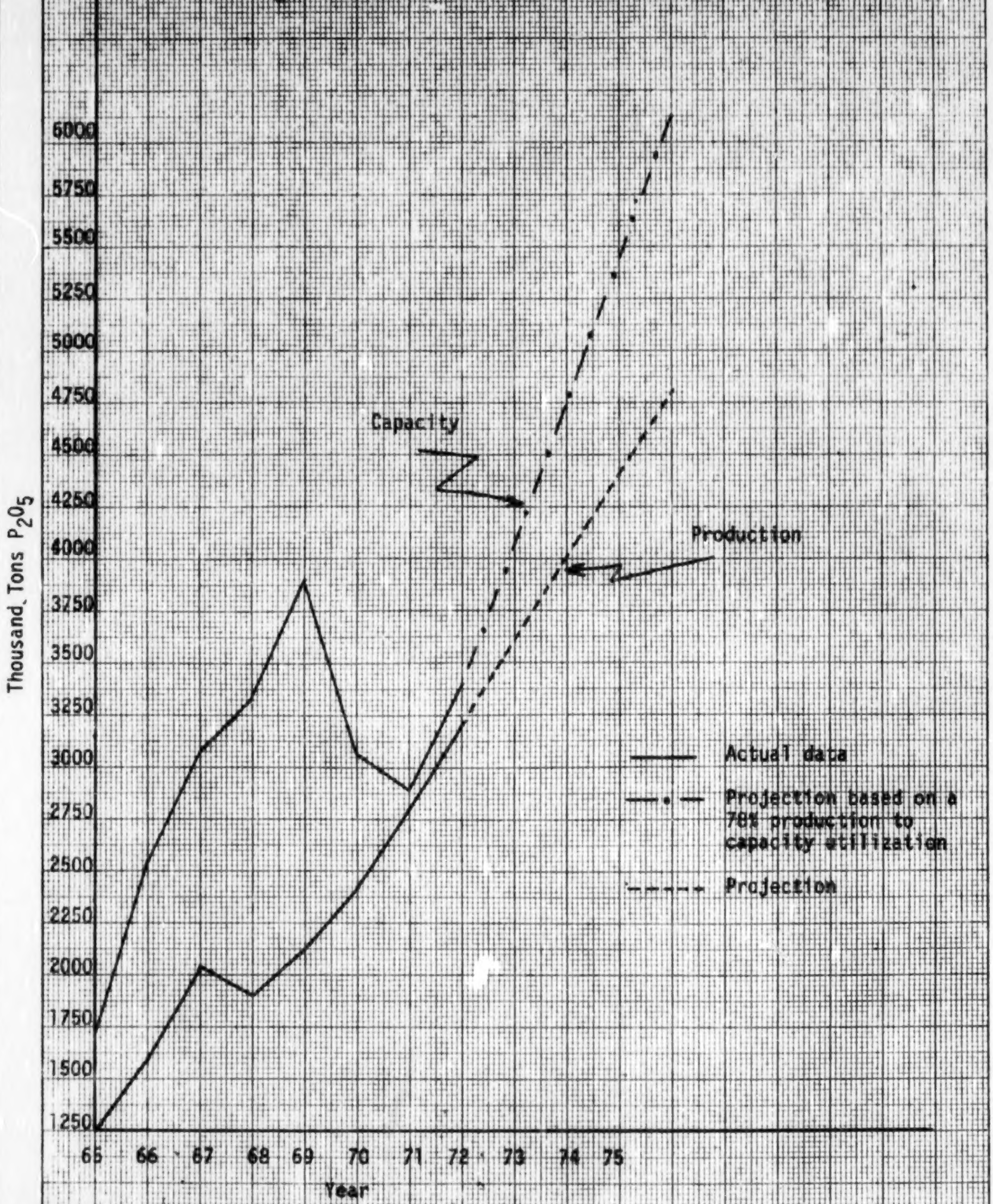
	Production, as Percent of Capacity	
Year	WPPA	DAP
1965	100	72
1966	92	63
1967	80	66
1968	77	56
1969	69	54
1970	84	78
1971	96	96
1972	96	96
1973	89	--
1974	89	--
1975	83	--
1976	82	--

FIGURE 1. CAPACITY UTILIZATION OF WET-PROCESS PHOSPHORIC ACID



SOURCES: Development Planning & Research Associates, TVA

FIGURE 2: CAPACITY UTILIZATION OF AMMONIUM PHOSPHATES



SOURCE: Development Planning & Research Associates

TABLE 2. U.S. PHOSPHATE CONSUMPTION, 1960-1971
(1000 Tons P_2O_5)

Year	Total Consumption	Mixtures	Direct Application Materials		
			Diammonium Phosphates[b]	Superphosphates	Ammonium Phosphates[a]
1960	2572	2033	35	287	171
1961	2645	2069	63	303	188
1962	2807	2219	110	314	205
1963	3073	2474	177	318	205
1964	3378	2705	244	382	216
1965	3512	2816	302	403	204
1966	3897	3111	418	506	221
1967	4305	3503	451	517	224
1968	4452	3579	608	566	227
1969	4666	3724	724	657	207
1970	4574	3709	726	608	184
1971	4826	3966	814	611	179

[a] Includes grades 11-48-0, 13-39-0, 16-20-0, 21-53-0, and 27-14-0.

[b] Includes 18-46-0 and 16-48-0 classified as mixed fertilizer, as well as "direct application materials.

SOURCE: Tennessee Valley Authority, USDA.

During mid-1973, the industry was operating near capacity. Idle plants that had been shut-down during the 1968-1970 recession were being refurbished for production. Beker Industries is one example of a firm that purchased idle phosphate facilities from petroleum companies for acid and ammonium production. New plant construction as announced by Agrico Chemical and IMC will not provide significant additions to supply of phosphates until 1975 to 1976. By inspection of the profiles in Figures 2 and 3 and the operating ratios presented above, planned plant capacity for phosphoric acid seems sufficient through 1976; and ammonium phosphate capacity, on the other hand, will have to be increased to cope with the projected demand.

D. Consumption

For an understanding of the historical consumption patterns of the four commodities named above, an overview of consumption of all phosphate fertilizers is presented. Although some superphosphoric acid is consumed ultimately in the form of animal feed supplements, almost all phosphate production from wet-process phosphoric acid ends up in fertilizers.

Historical data are presented for U.S. consumption (total consumption, mixtures, and direct application materials) in Table 2. Liquids and solids (bulk and bagged) are all included in these data. Total consumption includes phosphate values derived from wet-process phosphoric acid to produce triple superphosphate, and phosphate rock reacted with sulfuric acid to produce normal superphosphate.

Overall, the growth trend in total consumption has been at a rate of 6.5 percent compounded annually from the base year 1960. However, normal superphosphate production has declined steadily from 1,270,000 tons (P_2O_5) in 1960 to 670,000 tons (P_2O_5) in 1970. The gap in phosphate values generated by the decline in NSP has been mostly taken up by diammonium phosphate production, as well as wet-process phosphoric acid, the intermediate product. Hence, consumption of wet-process phosphoric acid and diammonium phosphate production have grown at a more rapid rate than total consumption of phosphates.

The two other major categories presented in Table 2 separates the basic chemicals that are applied directly to the soil from those that receive further processing into mixtures; foods containing at least two of the nutrients basic to plant growth. Some duplication of reporting is evident in the TVA statistics as some undetermined amount appears twice, in "mixtures" and "direct applications".

Review of the data in Table 2 shows that demand for materials with only one or two basic nutrients, the ammonium phosphates, has been very important in recent years. Ammonium phosphates, other than DAP, and normal superphosphate have declined in importance as "direct application materials". Almost all direct application materials are now DAP or GTSP. Demand for these materials appears to have grown more rapidly than total consumption. Two explanations for this trend are the rise of bulk blending operations and intensive cultivation (emphasis on increased yield per acre).

Delivery of low cost fertilizer materials to the farm has been the factor responsible for this trend. Farmers have lately realized that mechanical blends of granulated concentrates do just as well as a granulated, chemically produced NPK food and at lower costs. A shift from normal superphosphate and run-of-pile triple superphosphate production to the granulated concentrates, DAP and GTSP is seen.

The shift in product usage has also been accompanied by a shift in raw materials for NPK plants. Run-of-pile triple superphosphate has been replaced by wet-process phosphoric acid as a raw material. Improvement in phosphoric acid technology has made it possible to ship a stable product, as most NPK plants are far removed from the areas of acid production (Florida, for example).

Consumption of superphosphoric acid is only recently beginning to enter an important expansion phase. Data for consumption is limited. To this point in time, the acid has been used for producing some animal feed supplements and mostly liquid fertilizers. Superphosphoric acid consumption is estimated at only 15 percent of overall phosphate consumption.

Several reasons are presented to explain the expected expansion of superphosphoric acid consumption. Technology has made it possible to produce a product without the problems of sludge formation due to presence of micronutrients. Increased crop yield per unit P_2O_5 applied from liquids fertilizers has been claimed. Transportation and distribution costs of liquids are less than for solid fertilizers. The need for foreign exchange spurs superphosphoric acid production, particularly in light of the recent Occidental Petroleum announcement of a 20 year trade deal with Russia.(5)

The implications of all the shifting patterns in the industry in response to shift in demands for cheaper, better quality products are as follows:

1. Granular concentrates will continue to expand in production; these include DAP and GTSP.
2. Run-of-pile production will decline and be replaced by GTSP (bulk blender) and diammonium phosphate.
3. Superphosphoric acid will have the largest growth rate of the four commodities These will be important factors in determining growth rates for each process segment and the number of new units.

E. New Units

Future growth for consumption of fertilizers has been estimated at 5.4 percent annually from the base year of 1971(6) by the Department of Commerce. TVA estimates overall consumption of P_2O_5 to be 4 percent from 1970 to 1980.(7) Projection of new units will be determined from use of projected growth rates, capacity utilization, and estimated shifts in demand. Due to the present situation in this industry, attrition through 1980 is expected to be minimum (with the exception of normal superphosphate processing).

1. Wet-Process Phosphoric Acid

For purposes of discussion, the announced construction of wet-process phosphoric acid plants is assumed to satisfy demand through 1976 and will be unaffected by the recommended standards of performance. This includes the Agrico and the IMC facilities, which recently have commenced construction.

A growth rate of 5 to 8 percent in wet-process phosphoric acid production can be expected to accommodate overall phosphate demand for domestic consumption and exports growth and to replenish gaps left by normal superphosphate production. Calculations of added capacity needed to supply this demand will yield annual expansion of approximately 600,000 tons (P_2O_5 basis) for a 6-percent growth rate. For the 1976 through 1980 time frame, this will amount to 10 units of the 900-TPD size or 18 units of the 500-TPD size.

2. Diammonium Phosphate

From interpretation of available statistics, there is apparently a catch-up phase expected for this category in terms of present capacity utilization and expected demand growth.

Overall, the growth rate of ammonium phosphates is projected at 6 percent to correspond with the similar increase in wet-process phosphoric acid. It is difficult to predict number of new units to be affected by the standards of performance because they apply only to units that produce diammonium phosphate only in a single process. Much of the projected growth in ammonium phosphates will be supported by NPK production.

A conservative assumption for determining number of new diammonium phosphate plants would be to assume that three-fourths of production for each new wet acid plant will be devoted to solids manufacture, either DAP or GTSP. This would allow the remainder to be sold as merchant wet-process phosphoric acid or superphosphoric acid. This is based on past performance of the concentrates producers, such as those in Florida. In actual estimates then, there will be approximately 20 DAP units of the 500-TPD size through 1980.

3. Triple Superphosphate (Granular Only)

Based on earlier discussion, only granulated concentrates are expected to be of importance in the future for the triple superphosphate. Furthermore, only those producers of wet-process phosphoric acid will manufacture triple superphosphate as has happened mostly in the past.

According to information sources in the industry, the trend in granular production is to conduct triple superphosphate processing in the same facility producing diammonium phosphate. The only additional requirement for GTSP production in a DAP plant would be the storage facility.

For purposes of determining new storage units, an assumed growth rate of 4 percent in current granular production (approximately 700,000 tons per year P_2O_5) will yield 2-3 units (250-TPD P_2O_5) through 1980. This growth rate would be consistent with past performance for all triple superphosphate production.

4. Superphosphoric Acid

From all indications, this portion of the industry is expected to expand rapidly. Whether this expectation is realistic or a reflection of bold optimism is unknown. Ultimately, the availability of merchant wet-process phosphoric acid will be the factor that determines the constraints on SPA expansion.

For the industry as a whole, only enough expansion will occur to convert available acid that is not used to produce concentrates. This is axiomatic if the industry is to operate profitably. Approximately twent-five percent of all future WPPA expansion can be projected to accomodate SPA plants. Taking into account the Agrico and IMC combined new facilities (1,000,000 tons P_2O_5 per year total) and the projected expansion from 1976 through 1980, some 10 SPA plants will be built (300-TPD P_2O_5).

F. Prices

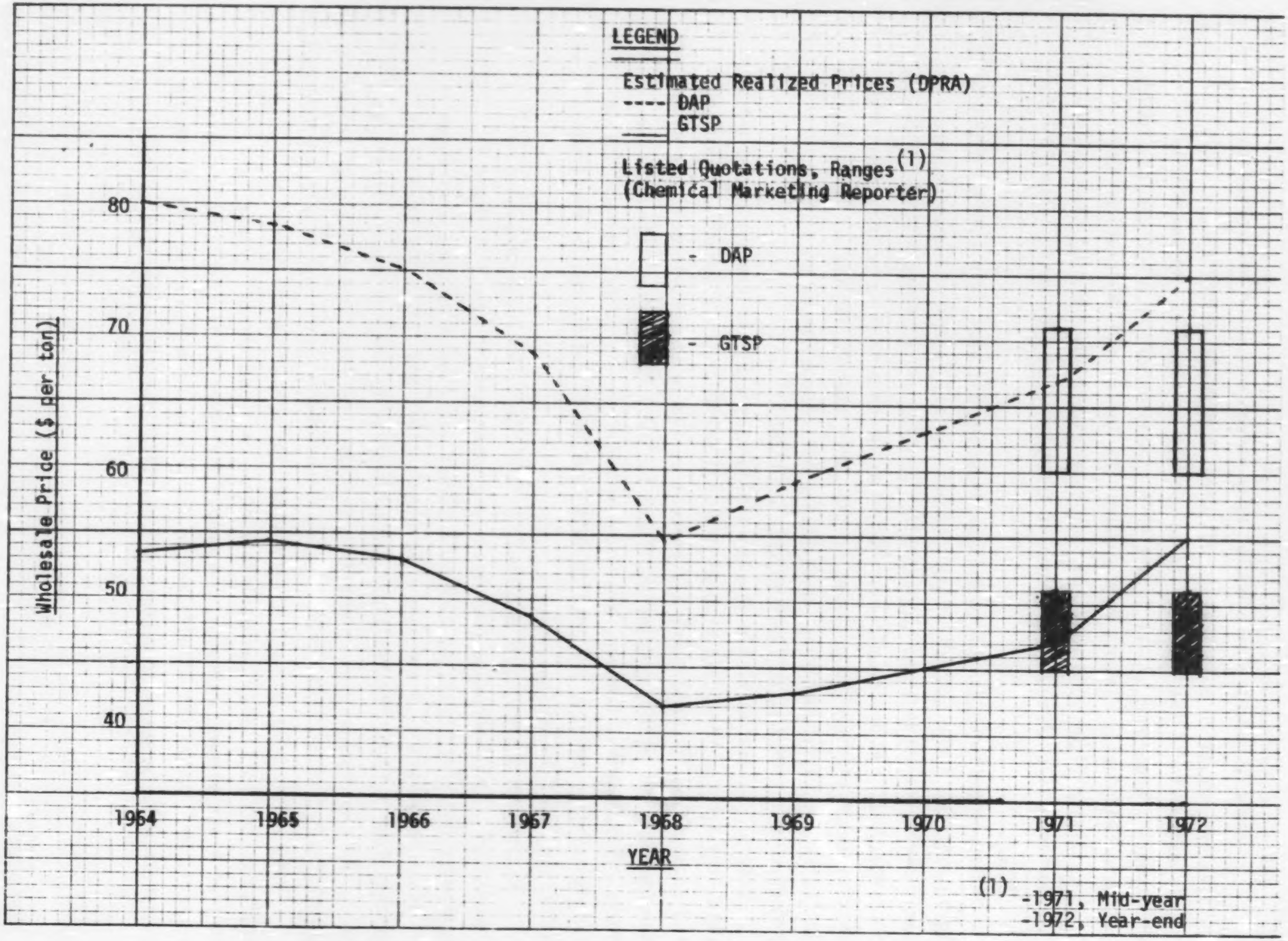
Price competition in the fertilizer industry has been very intense historically because of the large numbers of participants in all facets of manufacturing--basic chemicals production, down-the-line manufacturers of mixed goods, blenders, and retailers. No one chemical producer can be said to be a price leader. The participation of farm cooperatives in the manufacturing segment of fertilizers, including the basic chemicals, undoubtedly has been a steadying factor on prices, minimizing cyclic fluctuations in prices.

List prices are available for (agricultural grade) wet-process phosphoric acid, triple superphosphate (run-of-pile and granular), diammonium phosphate, and superphosphoric acid grade (72 percent available phosphoric acid basis) in the Chemical Marketing Reporter published by Snell Publishing Company of New York. These prices, however, are not meaningful as discounts, variability in credit terms to buyers, and service fees combine to determine the realized price available to the producer.

The long term profile of wholesale prices for triple superphosphate (granular) and diammonium phosphate is presented in Figure 3. The estimates of prices realized by manufacturers are plotted against the ranges of listed quotations of the same products for 1971 and 1972. The spreads in prices shown reflect the difference in quotations by various manufacturers at any given time rather tnan variability in time. No long term profile of prices is available for wet-process phosphoric acid, superphosphoric acid, and triple superphosphate.

These prices will be used as parameters for measuring the impact of pollution control. Total annualized control cost and the difference in control costs between existing, comparably stringent state standards and proposed Federal standards of performance for triple superphosphate and diammonium phosphate will be measured against prices (1972) for the respective products.

FIGURE 3. WHOLESALE PRICES FOR TRIPLE SUPERPHOSPHATE AND DIAMMONIUM PHOSPHATE



(1) -1971, Mid-year
-1972, Year-end

A summary of list prices (December 25, 1972) is presented in Table 3 for all commodities concerned. Point of origin for all quotations is Florida. Prices are based on largest volume available, railroad cars or tanks.

On October 25, 1973, prices on wholesale phosphate commodities were decontrolled. Prices had been frozen at levels established near year-end 1972 prices by President Nixon's Economic Stabilization Program. According to the Cost of Living Council, prices have advanced 60 percent from the October 25 frozen level to January 8, 1974.

G. Foreign Trade

Trade statistics for triple superphosphate and ammonium phosphates (mostly DAP) are presented in Table 4. No data are available for phosphoric acid (wet-process or SPA), probably for the reason that trade has been non-existent because of transportation properties associated with movements of acids.

As the data show, the U.S. has been an exporter of phosphates, on balance. The reasons for this include technological competition, favorable location of rock, and the Agency for International Development (AID). Under AID, export purchases of products have been possible by underveloped nations through U.S. foreign aid. AID providestechnical assistance, as well as financing of fertilizers, to these nations in fertilizer applications.

The recent unilateral devaluation of the dollar has placed the domestic industry in a favorable position by pricing American products at discounts relative to the foreign currencies of competive producing nations. This should be beneficial to the domestic producers at least for the short to intermediate term.

TABLE 3. SUMMARY OF LIST PRICES AND BASIS FOR PHOSPHATE COMMODITIES

Commodity	Price ($ per actual ton)	Production Quality	Quotation Basis
Wet-process phosphoric acid (WPPA)	\$53.00-->\$67.00	52-54% P_2O_5	Delivered in Tanks, F.O.B. Florida works
Superphosphoric acid (SPA)	\$83.00	72% P_2O_5	Same as WPPA
Diammonium Phosphate (DAP)	\$55.00-->\$66.00	18%N 46% P_2O_5	Bulk Delivered, Railroad car lots, F.O.B. Florida
Run-of-Pile Triple Superphosphate	\$38.00-->\$43.70	46% P_2O_5 min	Same as DAP
Granular Triple Superphosphate	\$40.00-->\$46.50	46% P_2O_5 min	Same as DAP

SOURCE: Chemical Marketing Reporter

TABLE 4. U.S. IMPORT-EXPORT BALANCE FOR PHOSPHATE FERTILIZERS
(1000 Tons, P_2O_5 Basis)

Year	Exports		Imports[1]	Net Exports % of U.S. Production	
	Concentrated Superphosphates (ROP & GTSP)	Ammonium Phosphates	Ammonium Phosphates	Concentrated Phosphates	Ammonium Phosphates
1961	174	27	40	17	-4[2]
1962	228	42	57	24	-4
1963	270	65	46	24	4
1964	276	127	34	23	10
1965	233	112	61	16	5
1966	294	270	63	17	19
1967	291	445	74	20	21
1968	533	445	86	38	22
1969	361	330	96	27	13
1970	325	358	160	23	10

(1) No triple superphosphate is imported.

(2) Negative number indicates net import.

II. Control Costs for Affected Facilities

A. Introduction

The purpose of this section is to report the expected capital and annual costs to control emissions from wet-process phosphoric acid, superphosphoric acid, diammonium phosphate, and triple superphosphate (run-of-pile and granular) processes. Estimates of control costs will be presented for two model plants for each process. These estimates will be based on information developed from a study under contract with the Industrial Gas Cleaning Institute.(8) Comparisons of these data with industry data submitted to the Environmental Protection Agency will be presented and discussed. Cost-effectiveness considerations for fluoride control will be discussed.

B. General Discussion of Control Alternatives

Basically, venturi, cyclonic, and packed scrubbers are applied to moisture laden streams carrying fluorides from process plants. Each process stream has certain characteristics that require various service functions--(1) recovery of ammonia or phosphoric acid which are valuable materials, (2) gaseous fluoride control, and (3) dust recovery from granulation. These functions will come into focus as model plants for the various processes are discussed.

These scrubbers will be referred to as primary and secondary collectors. Primary scrubbers serve to remove particulates, phosphoric acid mists, and ammonia. Secondary collectors perform gaseous absorption. Pond water is the general scrubbing medium, except for weak phosphoric acid used to recover ammonia (DAP plants).

C. Control Costs--Acid Manufacture

1. Wet-Process Phosphoric Acid

Model plants producing 500 and 900 ton per day (P_2O_5) are presented in Table 5 for WPPA plants. Capital and annual costs are presented for packed scrubbers with the scrubbing liquid sprayed on the packing perpendicular to the direction gas flow designed to remove fluorides. Capital costs include a scrubber, fan, water circulating pumps, 120 feet of ductwork, and a 100 foot stack. All surfaces exposed to scrubbing (pond) water are coated with polyvinyl chloride (PVC) or similar corrosion resistant material.

TABLE 5

CAPITAL AND ANNUAL COST FOR PACKED SCRUBBER ON WPPA PLANTS

Plant Size, TPD P_2O_5	500	900
Gas Flow, SCFM	25,000	36,000
Capital Cost ($)		
Scrubber	17,700	21,600
Auxiliary equipment (fan, pumps, etc.)	8,500	9,400
Installation Cost	36,300	40,900
Total Capital Cost	62,500	71,900
Annual Cost ($/yr)		
Operating labor	2,000	2,000
Maintenance (5%)	3,100	3,600
Utilities	2,800	4,400
Depreciation (10 yr)	6,250	7,200
Interest (8%)	5,000	5,750
Property Tax, Ins. (2%)	1,250	1,450
Administrative (5%)	3,100	3,600
Total Annual Cost	23,500	28,000

For the models, the packed scrubber is designed to meet the standard under most operating conditions, using pond water as the scrubbing medium. The scrubbers are assumed to be designed for approximately 4.5 transfer units, with a corresponding pressure drop of approximately 4 inches, water gauge.

The annual control cost per ton P_2O_5 ranges from \$0.135 to \$0.221 for the 500-TPD plant and \$0.08 to \$0.152 for the 900-TPD plant. These ranges are a reflection of the variability in gas flows previously discussed.

2. Superphosphoric Acid

Costs for the vacuum evaporation process are not considered since, as mentioned earlier, the process can probably achieve the level of the standard without air pollution control. Model plants are presented for the submerged combustion process.

For the submerged combustion process for producing superphosphoric acid, control technology to meet the standard of performance has not been tested to determine compliance. Experts in EPA feel that technology transfer of a venturi cyclonic-packed scrubber from applications on other phosphate processes is possible to achieve the standard.

For a 300-TPD P_2O_5 model plant, capital and annual control costs estimates are presented in Table 6 for a combination system that would be found on a diammonium phosphate drier or reactor. The basis for developing these estimates is the background data presented in Table 7. The cost for the packed scrubber was slightly adjusted to correct for increased packing depth (to 8.9 NTU). A gas flow rate of 8,000 scfm was assumed for determination of the costs. The cost of control on a unit basis is \$0.28 per ton P_2O_5.

TABLE 6

CAPITAL AND ANNUAL CONTROL COSTS FOR SPA PLANTS (SUBMERGED COMBUSTION PROCESS)

Control Equipment	Venturi scrubber with cyclonic separator followed by a packed scrubber
Gas Flow Rate ACFM	8,000
Capital Costs ($)	
Collector	18,400
Auxillary Equipment (fans, pumps, ductwork, instrumentation)	9,500
Installation Cost	41,000
Total Capital Cost	68,900
Annual Cost ($/yr)	
Operating Labor	2,000
Maintenance (5%)	4,000
Utilities	5,010
Depreciation (10 yr)	6,920
Interest (8%)	5,540
Property Tax and Insurnace (2%)	1,380
Administration (5%)	3,460
Total Annual Cost	27,800

The system outlined above to meet the standard does not remove any sulfur oxides emissions to any known extent. The system is designed to remove only particulate and fluoride emissions.

D. Control Costs - Phosphate Fertilizer Manufacturing

Capital and annualized cost estimates for emissions control are presented in Table 7 for five generic types of devices used in phosphate fertilizer manufacturing. These estimates are presented on an uniform dry gas flow basis. Moisture and temperature considerations will dictate the final size selection as capital estimates for the model plants will be based on the actual gas flow input. Utilities requirements will be directly proportional to actual gas flow input.

Capital costs include the basic scrubber, the fan, interconnecting ductwork from the scrubber to the 50-foot stack (assumed height), which is included, and a return pump. Materials of construction include rubber-lined mild steel or Dynel lined fiberglass reinforced plastic (FPP). Costs for a pumping system to recycle gypsum pond water and the construction and maintenance of the gypsum pond itself are not included. These costs are assumed to have been assimilated into the cost structure of the fertilizer industry.

1. Diammonium Phosphate (DAP)

Model plants producing 500 and 800 tons of P_2O_5 with engineering specifications for estimating costs are presented in Table 8. There are three distinct gas streams that must be vented to a scrubber system--(a) reactor-granulator, (b) the drier, and (c) the cooler and combined exhausts from elevators, screens, and transfer points. Those streams in the solids processing area pass through dry cyclones for product recovery before passing through the scrubbers. Each scrubber system includes a venturi with a cyclonic section (a two stage cyclonic scrubber may be a substitute device) as the primary collector for particulate removal and a packed scrubber for the gaseous fluoride removal.

Weak (30%) phosphoric acid is the scrubbing medium for the primary collectors for purposes of ammonia recovery. The cyclonic section is an entrainment separator for phosphoric acid mists. Pond water serves as the scrubbing medium for the packed scrubbers.

TABLE 7. CAPITAL AND ANNUAL CONTROL COSTS FOR PHOSPHATE MANUFACTURING PROCESSES

Scrubber Type	A Venturi Cyclone	B Two-Stage Cyclonic	C Venturi-Packed	D Cyclonic	E Packed
Typical Gas to Scrubber, ACFM	55,700	55,700	40,900	205,000	54,700
Design Gas Flow Rate, DSCFM	30,000	30,000	30,000	200,000	30,000
Application	Reactor, Drier, Cooler (DAP)	Reactor, Drier, Cooler (DAP)	GTSP Drier	GTSP Storage	Tail Gas Service (A, B)
Capital ($)					
Scrubber	44,400	66,400	36,900	101,000	27,400
Auxiliary Equipment	28,500	21,800	22,800	109,000	13,700
Installation	88,800	102,000	86,200	333,500	38,500
Total Capital Cost	161,700	190,200	145,900	543,500	79,600
Scale Factor	0.70	0.65	0.70	0.70	0.70
Annual Cost ($/yr)					
Operating Labor	2,000	2,000	2,000	2,000	2,000
Maintenance (5%)	8,000	9,500	7,300	27,200	4,000
Utilities	31,400	21,000	38,000	76,000	4,800
Depreciation (10 yr)	16,200	19,000	14,600	54,300	8,000
Interest (8%)	12,900	15,200	11,700	43,500	6,400
Property Tax, Ins. (2%)	3,200	3,800	2,900	10,900	1,600
Administrative (5%)	8,000	9,500	7,300	27,200	4,000
Total Annual Cost	81,700	80,000	83,800	241,100	30,800

TABLE 8. ENGINEERING SPECIFICATIONS FOR ESTIMATING COSTS FOR DIAMMONIUM PHOSPHATE PLANTS

Model Plant Size (P_2O_5)	500-TPD		800-TPD	
Process Source	Primary Collector	Secondary Collector	Primary Collector	Secondary Collector
A. Reactor-Granulator				
Effluent Volume, DSCFM	20,000	20,000	32,000	32,000
Gas to Scrubber, ACFM	40,000	38,000	64,000	61,000
Moisture Content, %	40	41	40	41
Gas Temperature, °F	170	135	170	135
Scrubber Media	30% H_3PO_4	Pond Water	30% H_3PO_4	Pond Water
B. Drier				
Effluent Volume, DSCFM	30,000	30,000	48,000	48,000
Gas to Scrubber, ACFM	55,700	53,500	89,000	85,500
Moisture Content, %	35	36	35	36
Gas Temperature, °F	180	164	180	164
Scrubber Media	30% H_3PO_4	Pond Water	30% H_3PO_4	Pond Water
C. Cooler-Transfer Points				
Effluent Volume, DSCFM	30,000	30,000	48,000	48,000
Gas to Scrubber, ACFM	35,000	34,200	56,000	54,700
Moisture Content, %	3	4	3	4
Gas Temperature, °F	140	120	140	120
Scrubber Media	30% H_3PO_4	Pond Water	30% H_3PO_4	Pond Water

A summary of control costs for the model plants is presented in Table 9. A two-stage cyclonic scrubber is assumed for the reactor-granulator stream, and venturi cyclones for the drier and cooler-transfer points streams. The venturi should remove particulates from the latter streams more effectively than a two stage cyclone although both types are interchangeable. Total control costs with NH_3 credits are \$0.88 per ton P_2O_5 for the 500-TPD plant and \$0.70 for the 800-TPD plant. Gaseous fluoride control costs alone are \$0.46 per ton P_2O_5 for the 500-TPD plant and \$0.40 for the 800 TPD plant.

2. Triple Superphosphate (GTSP and ROP)

In reference to earlier discussions, granular triple superphosphate will be produced in the same facilities as diammonium phosphate. The same basic control equipment could be used in the manufacture of both products, although triple superphosphate production requires approximately twice as much recirculation of solids during granulation as does DAP per unit output. Hence, gas volumes generated for equivalent P_2O_5 production will be significantly larger for triple superphosphate. In addition, storage ventilation will require scrubbing.

Engineering specifications for estimating control costs are presented in Table 10 for two models to produce 250-TPD and 400-TPD P_2O_5. Venturi-packed systems are assumed installations for models in lieu of venturi-cyclonic and packed combinations. This would be the situation for the facilities where ammonia recovery is practiced only at the reactor-granulator during DAP processing.

A summary of control costs for granular triple superphosphate production is presented in Table 11. Unit costs for all control systems are \$3.96 per ton P_2O_5 for the 250-TPD model and \$3.56 per ton P_2O_5 for the 400-TPD plant. Storage control costs alone are \$0.57 per ton P_2O_5 for the smaller plant and \$0.50 per ton P_2O_5 for the larger plant.

Run-of-pile triple superphosphate production requirements for emissions control to meet the standards of performance are presented in Table 12. Gas streams from the den, cutter, and

TABLE 9. CAPITAL AND ANNUAL CONTROL COSTS FOR DIAMMONIUM PHOSPHATE PLANTS

Model Plant Size (P_2O_5)	500-TPD		800-TPD	
Process Source	Primary Collector	Secondary Collector	Primary Collector	Secondary Collector
A. Reactor-Granulator				
1. Capital ($)	155,000(1)	60,000	210,000	83,400
2. Total Annual Cost ($)	62,500	23,000	87,400	32,100
B. Drier				
1. Capital ($)	162,000(2)	80,000	225,000	111,000
2. Total Annual Cost ($)	82,000	30,800	120,000	43,000
C. Cooler & Transfer Points				
1. Capital ($)	118,000(2)	57,000	164,000	79,200
2. Total Annual Cost ($)	57,000	22,100	83,000	30,800
Summary				
Total Capital ($)	632,000		873,000	
Total Annual Cost ($)	277,400		396,300	
Unit Control Cost ($/ton P_2O_5)	1.68(3)		1.50(3)	
Unit Control Cost with NH_3 credits(4) ($)	0.88		0.70	

(1) Two-Stage cyclonic for both model plant sizes.

(2) Venturi cyclone for both model plant sizes.

(3) 330 days per year operation.

(4) Value of NH_3 taken at $40 per ton. Recovered NH_3 is estimated at 80 lbs per ton NH_3 feed for all sources combined.

TABLE 10. ENGINEERING SPECIFICATIONS FOR ESTIMATING COSTS FOR GRANULAR TRIPLE SUPERPHOSPHATE PLANTS

Model Plant Size (P_2O_5)	250-TPD		400-TPD	
	Primary Collector	Secondary Collector	Primary Collector	Secondary Collector
A. Reactor-Granulator				
Effluent Volume, DSCFM	20,000	20,000	32,000	32,000
Gas to Scrubber, ACFM	25,400	22,700	40,600	36,300
Moisture Content, %	11	7	11	7
Gas Temperature, °F	140	100	140	100
B. Drier				
Effluent Volume, DSCFM	40,000		64,000	
Gas to Scrubber, ACFM	54,700		87,000	
Moisture Content, %	12		12	
Gas Temperature, °F	180		180	
C. Cooler-Transfer Points				
Effluent Volume, DSCFM	50,000		80,000	
Gas to Scrubber, ACFM	58,000		93,000	
Moisture Content, %	3		3	
Gas Temperature, °F	140		140	
D. Storage				
Effluent Volume, DSCFM	98,400		157,400	
Gas to Scrubber, ACFM	100,000		160,000	
Moisture Content, %	2		2	
Gas Temperature, °F	80		80	

TABLE 11. CAPITAL AND ANNUAL CONTROL COSTS FOR GRANULAR TRIPLE SUPERPHOSPHATE PLANTS

Model Plant Size (P_2O_5)	250-TPD		400-TPD	
	Primary Collector	Secondary Collector	Primary Collector	Secondary Collector
A. Reactor-Granulator				
1. Capital	93,300[1]	43,700	130,000	60,700
2. Total Annual Costs	44,300	17,000	64,000	23,400
B. Drier				
1. Capital	179,000[2]		247,000	
2. Total Annual Costs	106,500		157,000	
C. Cooler & Transfer Points				
1. Capital	186,000[2]		259,000	
2. Total Annual Costs	111,700		160,000	
D. Storage				
1. Capital	121,000[3]		169,000	
2. Total Annual Costs	47,220		66,600	
Summary				
Total Capital ($)	623,000		866,000	
Total Annual Cost ($/yr)	327,000		471,000	
Unit Control Cost ($/ton P_2O_5)	3.96		3.56	

[1] Venturi-cyclone on both model plant sizes.

[2] Venturi-packed type on both model plant sizes.

[3] Packed scrubber on both models.

NOTE: Pond water scrubbing media for all control devices.

TABLE 12.

CAPITAL AND ANNUAL CONTROL COSTS FOR RUN-OF-PILE TRIPLE SUPERPHOSPHATE PRODUCTION

Model Plant Size (P_2O_5)	250-TPD	400-TPD
A. Engineering Specifications:		
Gas to Scrubber, ACFM	60,000	100,000
Collector	Venturi Cyclone	Venturi Cyclone
Scrubbing Medium	Pond Water	Pond Water
B. Cost Summary		
1. Capital Requirements ($)	315,000(1)	450,000(2)
2. Total Annual Cost ($)	135,000	200,000
3. Unit Control Costs ($ per ton P_2O_5)	1.64	1.52

(1) Scrubber portion of costs is $60,000; auxiliary and installation costs are $255,000.

(2) Scrubber portion of costs is $90,000; auxiliary and installation costs are $360,000.

storage are assumed to be combined and treated in a central collection system. This is generally the practice in industry today. Control technology consists of a venturi cyclone followed by a packed scrubber, all with pond water as the scrubbing medium.

For the selected model plants, unit control costs are $1.64 per ton P_2O_5 for the 250-TPD plant and $1.52 per ton P_2O_5 for the 400-TPD plant. The basis for the capital estimates are the purchase costs of the venturi cyclone (A) in Table 7 and for the packed scrubber in (E); with auxiliary and installation costs for a storage facility (D).

E. Documentation of Reported Industry Data

All data reported to EPA by industry for emissions control systems which are considered best demonstrated technology for their respective process plants have been compiled and analyzed. A tabulation of these data and EPA estimates derived for comparable bases are presented in Table 13. The industry reporting has been sparse, and only qualitative inferences can be drawn from their analysis.

Statistics are presented in Table 13 for process capacity, plant (battery limits) capital, control systems, capital, and year of installation. The capital estimates reported by industry are in actual dollars and have not been corrected for inflation. EPA estimates are in 1973 dollars and have been developed from plant models presented earlier. Operating costs have not been analyzed due to insufficient, inconsistent reporting.

In general, capital estimates of fluoride emissions control systems are in agreement with EPA estimates for wet-process phosphoric acid, superphosphoric acid, and granular triple superphosphate processing. EPA estimates for run-of-pile production appear low probably because the costs for piping and ductwork associated with ventilating the storage area have been omitted.

TABLE 13

COMPARISON OF INDUSTRY REPORTED DATA AND EPA ESTIMATES FOR EMISSION CONTROL SYSTEMS

Plant	Process	Size (P_2O_5 Basis)	Industry Reported Plant Capital		Year Installed	EPA Estimate of Control System Capital ($MM)	Remarks (Industry Data)
			Process ($MM)	Emissions Control ($MM)			
A	WPPA	550-TPD	5.9[(a)]	0.19	1965	0.065	Includes more duct-work and piping, as well as dust collectors, all excluded from EPA estimates.
B	WPPA	600-TPD	3.4	0.18	1965	0.065	
C	GTSP (Plant) (Storage)	300-TPD 17,000 Tons	2.7[(a)] 0.50	0.37 0.44	1966 1967	0.57 0.34	Retrofit project. Gas flow rates for reported data & EPA estimate are same.
D	WPPA-DAP	600-TPD	9.9	1.5	1967	0.80	Includes all cost associated with ventilating and emissions removal on both DAP and WPPA plants.
E	WPPA	1,000 TPD (2 units)	6.2	0.35	1966	0.12	
F	SPA (Vacuum Evap.)	300-TPD	2.8	0.02	1966	0.01-0.02	
G	SPA (Submerged)	300-TPD	2.9	0.15	1966	0.15	
H	SPA (Submerged)	200-TPD	2.0	0.12	1966	0.15	

(a) 1973 Replacement Cost

In terms of percents of battery limits plant capital, emissions controls for solids processing as shown by the data for ROP and GTSP, are the highest for any process. Emissions control capital ranges from 15 to 25 percent of battery limits plant capital for these processes. Control systems for wet-process phosphoric acid production are 5 to 10 percent. Controls for superphosphoric acid production are about 6 percent for the submerged combustion process.

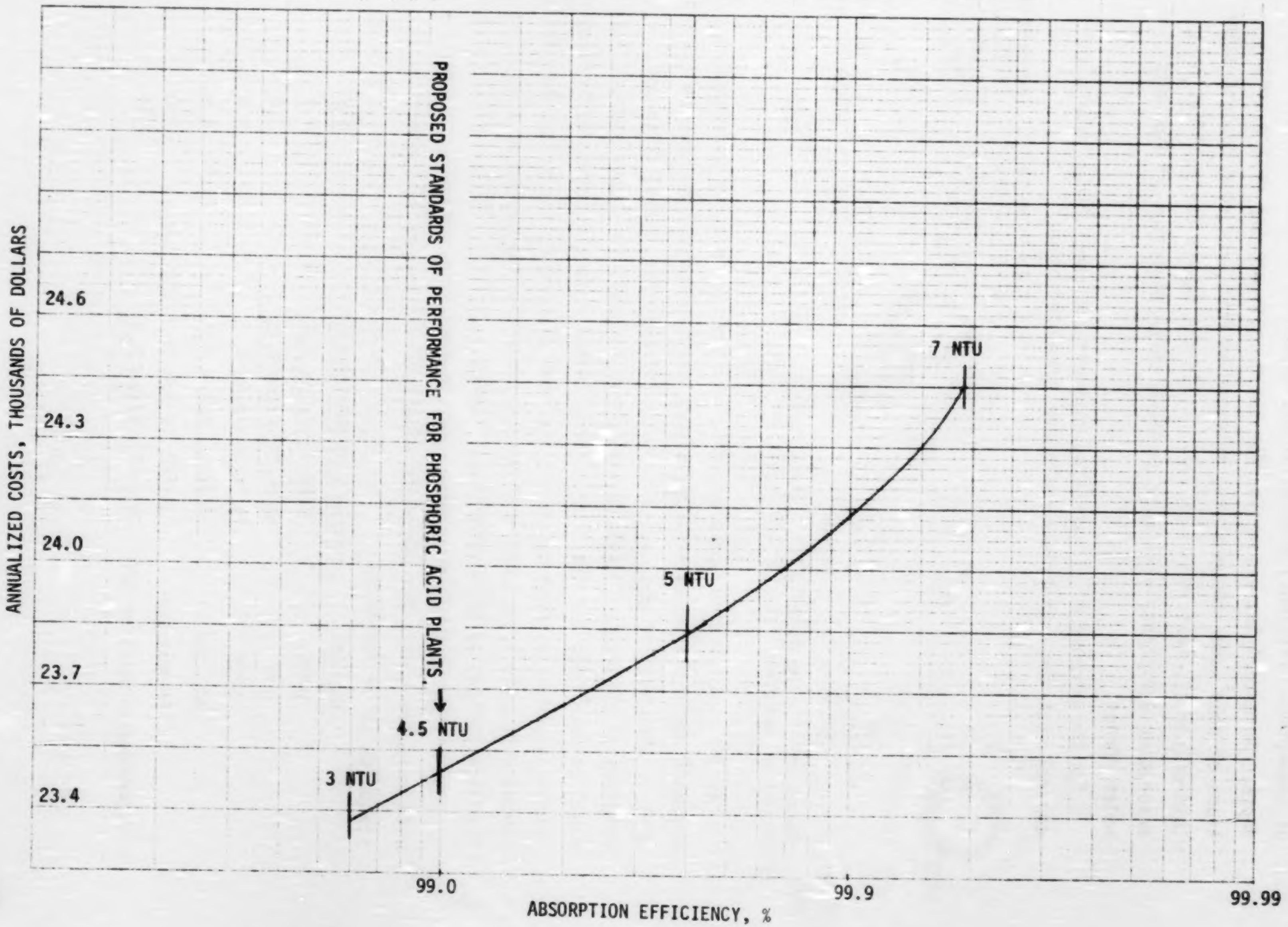
No conclusions can be drawn from the reported industry data concerning the impact of the recommended standards of performance

F. Cost-Effectiveness

All processes considered for standards of performance have been assumed to require packed scrubbers as the best available demonstrated control technology. The effectiveness of these scrubbers is based on the principle of a concentration gradient between gaseous fluorides in the effluent stream and the vapor phase in equilibrium with the scrubbing medium. The outlet concentration of the clean gas is limited by the concentration of the fluorine in the pond water (which is somewhat a function of the pH) and the water temperature, both factors determining the vapor pressure of fluoride in equilibrium with the liquid phase of the scrubbing pond water. Removal efficiency, or adsorption efficiency (measured in transfer units) requirements depend on the concentration of fluoride in the process streams. Key design factors governing the number of transfer units are packing depth and packing materials.

The relationship of cost vs. adsorption efficiency for packed scrubbers common to the industry is presented in Figure 4 for a range of 3 to 7 transfer units. The annualized cost of the scrubber for a 500-TPD P_2O_5 wet-process phosphoric acid plant is selected as the parameter in Figure 4. The choice of the effluent gas stream of a wet-process phosphoric acid plant is appropriate in discussion of cost-effectiveness because this emission source is probably the most significant of all sources under consideration and offers a wide range

FIGURE 4. COST-EFFECTIVENESS PROFILE FOR PACKED SCRUBBERS



of absorption efficiency possibilities, depending on choice of packing depth. An underlying assumption for these costs are the design conditions of pond water temperature, selected as 80°F, and acid concentration (hydrofluoric), measured as pH 2.0. In the day-to-day applications, absorption efficiency will vary as these characteristics of the pond water change.

For the purpose of illustrating cost-effectiveness, four levels of control with the appropriate costs are presented below.

Level	Efficiency, %	Annual Cost, $(1)	Total Incremental Cost, $	Incremental Fluorides Captured, Tons/Year(2)	Incremental Cost per Incremental Ton, $
A	95.00	23,380	23,380	141	166
B	98.90	23,500	120	5.8	20.7 (B over A)
C	99.40	23,900	400	0.74	540 (C over B)
D	99.91	24,450	550	0.6	724 (D over C)

(1) Based on 500-TPD model plant (see Table 5)
(2) Based on emission rate of 1.8 F per ton P_2O_5.

As the results show, cost per unit of fluoride captured decreases somewhat above the base level efficiency of 95 percent. The reason for this is that much of the capital, which is spent for installation and erection of the control device, and operating costs for labor and utilities would be unchanged for the four control levels. As absorption efficiency approaches level D, cost per unit rises rapidly and will rise exponentially beyond D as pond water equilibrium conditions are approached by the fluoride content of the effluent gas stream.

The following tabulation shows the required transfer units to comply with proposed limits the phosphate manufacturing processes subject to standards of performance.

Source	Standards of Performance	NTU
WPPA	0.02 lb F/ton P_2O_5	4.5
DAP	0.06 lb F/ton P_2O_5	2.0
GTSP	0.20 lb F/ton P_2O_5	3.0
ROP-TSP	0.20 lb F/ton P_2O_5	4.5
GTSP storage	0.0005 lb per hr F/ton P_2O_5	1.0
submerged combustion SPA	0.01 lb F/ton P_2O_5	8.9

The emission data from which the above NTU's were derived are based on test data collected by EPA on those plants chosen for the best demonstrated control systems.

These data generally show that the proposed standards of performance for the various selected processes would appear on the lower end of the cost effectiveness curve, Figure 4. From the standpoint of total costs, setting a standard at higher levels, such as the requirement for SPA, would result in very negligible incremental costs. The overriding factor would appear to be a technical one. The pond water conditions represent the obvious constraint to achievement of high transfer units. Stripping of fluorides from feed materials in the various processes in quantities over what constitutes normal conditions would add to the inlet loadings to the scrubber and tend to increase the emission levels. Particulate plugging of scrubber packing would reduce effective absorption surface and efficiency.

In conclusion, the recommended standards and even standards at levels higher than those recommended are not prohibited by cost.

IV. Economic Impact of Standards of Performance

A. General Discussion

According to the Clean Air Act, promulgation of Standards of Performance for a designated pollutant would require States to formulate implementation plans with emission regulations for existing sources emitting fluorides in a manner similar to state implementation plans for attainment of National Ambient Air Quality Standards (NAAQS). As a result of this legal mandate, the economic impact of the proposed standards of performance may have farther reaching consequences than what the following analysis will show for new phosphate facilities. The economic impact of emission limitations on existing facilities that would result from the promulgation of state standards is not in the scope of this analysis.

B. Total Pollution Abatement

Development Planning and Research Associates (DPRA) conducted an investigation of the economic effects of water pollution abatement on the fertilizer industry. They presented model plant investments for appropriate model plant phosphate facilities. For example, for an integrated phosphoric acid plant complex producing diammonium phosphate as its final product, capital investments for double liming and primary clarification as specified water treatment are about \$4,000,000 for a 900-TPD (P_2O_5) plant compared with some \$40,000,000 total plant capital invested for phosphoric acid, ammonia, and solids processing facilities. Reported annual water abatement costs (depreciation, operating expense, maintenance costs) are approximately \$3.00 per ton P_2O_5 product. For the 500-TPD model plant, abatement costs are an approximate \$4.00 per ton P_2O_5. In terms of product price, these estimates would be approximately \$1.50 and \$2.00, respectively.

DPRA indicated that increased abatement costs for diammonium phosphate (and phosphoric acid, which is the intermediate product) could be passed on to the consumer to the extent of \$4.00 per ton product. This would allow the more efficient (and larger size) producers to pay for the water abatement equipment and maintain profitability at a rate equivalent to 8 percent or better on their capital investment. According to DPRA analysis, the smallest viable producer under this assumption would be a 170,000 ton per year plant (235-TPD P_2O_5). New plants entering the fertilizer market would be larger than this size because of increased investment requirements per unit capacity and higher expected rate of return for attracting new venture capital into this industry; hence, the rationale for the 500-TPD plant assumed as the "small model plant" in this analysis for the standards of performance.

The price increases are expected for the following reasons. The demand for fertilizer is fairly inelastic, cross elasticities between competitive phosphate products notwithstanding. Second the price level of all fertilizers is substantially lower than a decade ago, which has been possible through improvements in technology in ammonia and wet-process phosphoric acid processing. Thirdly, prices at the retail level are double those at the production level. Hence, a \$4.00 increase in DAP (or 6 to 7 percent of the producers' sales price) is only 3 percent at the consumer level.

With this background information on the ability of the fertilizer industry to pass along costs above current price levels, the impact of abatement under the standards of performance will be analyzed.

C. Impact of Control Costs on Model Plants

Table 14 presents a summary of annualized control costs for all the processes under consideration for standards of performance. The control costs are presented on both a total product basis and a P_2O_5 basis. Measure of control costs as a percent of sales is also presented for the various products. Lastly, a column for impacts due directly to Federal standards of performance is presented, that is, the difference in costs between the proposed Federal standards of performance and an existing stringent State regulation. The Florida regulations are deemed as the most stringent in the U.S. today and are assumed as the applicable State standard for comparison with the Federal standards of performance. The actual allowable effluents for the various processes under the Florida regulation are not comparable with those under the Federal standards of performance because of differences in emission measurement techniques. Therefore, model plant control configurations as presented in the tables in Section III are assumed to comply with Florida's standards; any control less effective than the model plant control configurations will not comply with Florida's regulation.

1. General Discussion of Plant Costs

As Table 14 shows, only triple superphosphate seems high in magnitude of costs relative to fluoride emissions control cost for other processes. The costs for granular triple superphosphate seem prohibitive, in particular; however, as pointed out earlier, a complex that can capably produce two products (DAP and GTSP) interchangeably with the same solids manufacturing facility can optimize utilization of the owner's capital by operating his phosphoric acid plant at full capacity and produce a product mix that will maximize his profits. It is important to point out that basically the same emission control equipment is used in both DAP and GTSP production.

If ammonia credits are excluded from the DAP recovery system, control costs for the average DAP plant (midway between 500-TPD and 800-TPD P_2O_5) would be \$1.60 per ton P_2O_5 for control of the reactor-granulator, drier, and cooler process streams. An estimate of costs for control

TABLE 14. IMPACT OF CONTROL COSTS NECESSARY TO MEET STANDARDS OF PERFORMANCE FOR ALL PHOSPHATE PROCESSING SEGMENTS

Process	Sales Price[3] ($ per ton P_2O_5)	Control Cost		Control Cost as % of Sales Price	Impact of Standards of Performance
		($/Ton P_2O_5)	($/Ton Production)		
Wet-Process Phosphoric Acid	195	0.12	0.06	0.06	None
Superphosphoric Acid	220			-	
a) Vacuum Evaporation		0.00	0.00	-	None
b) Submerged Combustion		0.28	0.20	0.13	0-$0.28 per ton P_2O_5 (0.25% of sales)
Diammonium Phosphate	261	0.79	0.36	0.3	Outside of Florida, use of secondary scrubber requirements cost $0.43 per ton P_2O_5 (0.3% of Sales)
Granular Triple superphosphate	119-198	3.74[1]	1.72[1]	1.9-3.1	Outside Florida,[2] storage requirements cost $1.61 per ton P_2O_5 (1.5% of Sales)
Run-of-Pile Triple superphosphate	82-188	1.58	0.73	0.8-1.9	None

[1] Includes storage control costs.

[2] Secondary scrubbers for drier and cooler might be approximately double (unit P_2O_5 basis) for similiar costs on a DAP plant. For example, estimated costs of $53,000 in Table for 500-TPD DAP plant would be incurred for the 250 TPD GTSP plant ($0.64 per ton P_2O_5 for GTSP).

[3] Second quarter 1974 prices - Chem. Marketing Reporter.

of similar process streams within the same plant for GTSP production would be \$2.60 per ton P_2O_5. Hence, GTSP processing would cost \$1.00 per ton more than DAP processing and require an additional \$1.60 per ton P_2O_5 for control of emissions during storage.

The costs of emissions control as shown in Table 14 for run-of-pile triple superphosphate are low in comparison with GTSP; however, ROP-TSP is an intermediate product sold to an NPK plant, which would have to granulate a finished product from this intermediate material and incur internal costs of emissions control in addition to the \$1.58 per ton P_2O_5 incurred at the ROP-TSP processing level. Therefore, the NPK plant operator would have to superimpose this incremental cost into his overall cost structure, which would include his own internal control expenses and the price of various phosphate substitutes (wet-process phosphoric acid, DAP, GTSP) available to produce NPK fertilizers.

The costs for the submerged combustion process of producing superphosphoric acid represent the annualized costs for application of a venturi-cyclone/packed scrubber system, that is a transfer of technology from diammonium phosphate production. The costs are presumed for a plant exhibiting no control although this is not quite the case as evident from industry correspondence. On the other side of the coin, the costs do not take into account engineering, design, testing, and start-up for a system that has not been effectively demonstrated on a submerged combustion plant.

2. Impact of Federal Standards over State Standards

Table 14 summarizes the cost differences between the Federal standards of performance and correspondingly stringent State standards. The state of Florida requires new plants to employ control systems as effective as those assumed in the model plant configurations, with one exception--the submerged combustion process for producing superphosphoric acid. Hence, one direct impact of the Federal standards of performance would be the imposing of a universal cost penalty of some 28 cents per ton P_2O_5 on the submerged process plant. As this amounts to only 0.13 percent of sales, there should be no impact.

For diammonium phosphate and GTSP facilities in States other than Florida, the Federal standards of performance would have a direct impact. Secondary scrubbers required for DAP facilities in these areas would cost an additional 43 cents per ton P_2O_5, storage facilities would require fluoride control at a cost of $1.61 per ton P_2O_5 manufactured. Triple superphosphate facilities in areas other than Florida probably have some fluoride emission control on the reactor, but probably not on driers and coolers in granulating facilities. Primary scrubbers would be required anyway for particulate emissions regulations applicable under NAAQS. Secondary scrubbers for fluoride removal on new GTSP plants in these areas might require an additional 64 cents per ton P_2O_5, in addition to the control costs for storage. As some 80 percent of triple superphosphate production is confined to Florida and will remain so in the future, the impact of the standards of performance will be minimal on this portion of the industry.

Lastly, there will be no impact on wet-process phosphoric acid plants or the vacuum evaporation production of SPA for emissions control imposed by the standards of performance. No impact is expected for ROP triple superphosphate because of declining trends in production, as cited earlier.

For plants built elsewhere than the state of Florida, some impact due to the standards of performance may be expected for diammonium and granular triple superphosphate for the reason that States other than Florida have not required as stringent control of fluorides.

D. Impact of Standards of Performance on the Phosphate Industry

For most of the processes under consideration for standards of performance, control costs associated with fluoride emission control are small. Assuming trends as shown in Figure 3, price increases seem to be in prospect in the forseeable future. The reasons for this are as follows: (1) with elimination of smaller, high cost operations, supply-demand relationships are improving for the producers, (2) effects of dollar devaluation provide an assist for the domestic industry by making exports more attractive to foreign markets, (3) internal dynamics of the industry trending toward bulk blending and liquids production which offer cost savings at the retailer level of the industry, and (4) increased crop production increasing demand for fertilizers as result of a current world-wide shortage of grain supplies. In general, cost increases in production as a result of promulgating standards of performance on new sources will be readily absorbed into increased prices at the consumer level.

One area of possible impact would be GTSP production. As this product competes with DAP for mixtures production, the higher costs under the standards of performance on a unit ton (P_2O_5) basis with respect to DAP would be a deterrent for the producer who sold in the market bidding for mixture materials. For a direct application of fertilizer to the soil, this situation would not exist and the GTSP producer would pass costs along.

As discussed earlier, the effects of the dollar devaluation should benefit agricultural fertilizer producers. As the magnitude of devaluation far overshadows cost increases for fluoride emission control, no impact on foreign trade is readily foreseen as a result of the promulgation of the Federal standards of performance.

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6. U. S. Industrial Outlook 1972 (With Projections to 1980), U. S. Department of Commerce, Bureau of Domestic Commerce, April 1972.

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